CONTRACTORS' PLANT AND MACHINERY

CONTRACTORS' PLANT AND MACHINERY

R. BARNARD WAY

London
CROSBY LOCKWOOD & SON LTD.
20, *Tudor Street, E.C.*4
1946

First Published 1946

Preface

So far there have been but few books put forward on this subject, and the reason for this is not far to seek. It would in fact be easier to write a book about the tools that the Public Works Contractor does *not* use, than to deal even superficially with those in his daily employ. It can be said, with little danger of contradiction, that no industry uses anything like the variety of machinery and gear that has to be kept on hand by anyone of standing in this business. So perhaps it should be with some trepidation that the author offers this work to those in the industry who, like himself, desire to know more about the engineering principles at the back of the machines he uses, as well as something of how those machines work.

Many tools are a closed book to the man who works them every day, but they need not be so, and should not be. The true workman will always respect his tools, and the more he knows of them the less likely he is to mishandle them. In these pages some attempt has been made to explain principles of working, but with the bewildering variety from which to make choice, it has not been possible to do more than skim the surface. To deal with all would require an engineering library, and by the time that had been got out, there would be almost as many new machines outside its pages as within. Such is the production of new tools and gear for this great industry, almost without parallel.

However this may be, there are still plenty of old tools and old machines still working and, between these and the new ones bought only yesterday, a vast assemblage of gear doing a useful job. Perhaps it is with a selection of these that this book may be said to deal, though we could not have it thought that there are no up-to-date examples included within its pages.

To whom is this book addressed ? First and foremost to the beginner in the contracting business. Along with him, all

those who want to know the how, why and wherefore of it all, but who find the language of the fully technical books beyond them. To these and everyone else who finds some interest in these pages the author would offer his apologies for any inadequacies or omissions.

R. BARNARD WAY.

Welwyn Garden, Herts.
July. 1945.

CONTENTS.

I	Instruments of Power	9
II	The Plant Engineer	30
III	Levelling The Site	39
IV	Cranes	65
V	Excavators	87
VI	Compressed Air	118
VII	Piles and Piling	145
VIII	Concrete Machinery	166
IX	Pumps	195
	Index	222

Chapter I

INSTRUMENTS OF POWER.

SOME of the machines that we shall see at work in our mind's eye in this book, and which many of its readers will often have seen in reality, are most impressive in action. The concentration of power on to a single operation, enabling work to be done in a few seconds that would take many hours to do by hand, never fails to attract the attention of the passer-by. Few of us can say truthfully that we have never stopped to watch the action of some machine at work in the streets, or by the roadside, and though we are now well accustomed to the sight of those most commonly in use, they still provide us with entertainment. Those of us who have enjoyed a certain amount of labour on the land, and who realise within a little just how much work really does go into digging out a cubic yard of virgin soil, perhaps realise the power of the mechanical excavator that can do that job in two bites, and can dump the soil into a lorry in less than one minute. Or compare the work of mixing up a couple of buckets of concrete for some domestic job or other, and the difficulties in making sure of an even consistency, with the sure and speedy methods of the giant mixers used in so many departments of civil engineering.

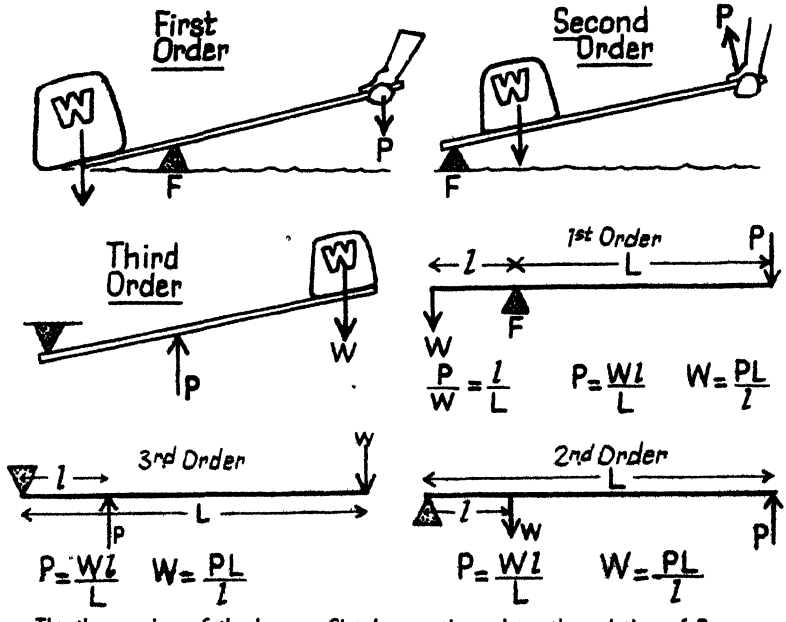
Much time and space could be taken up here with comparisons between the hand labour, that provided the whole battery of attack in days gone by, and the modern applications of the power of oil engines through mechanical means. Such comparisons are unnecessary at this stage, but will occur later as we proceed.

The machine, whatever its nature, makes use of the appliances

of power; these have been discovered during the period of man's life and work on this planet, and some of them are of immeasurable age, so much so that nobody can say for certain where they originated.

It seems in order, then, to commence this book with some mention of them, adding descriptions of the more subtle developments that are in reality based upon the elementary appliances.

The idea of the instrument of power is to spread out the labour necessary for a certain task over a long time or distance. In this way, the limited power of one man which, when applied directly to the work, would not be enough to do it suddenly, can easily do it if a longer time is permitted, and a distance a weight has to be moved may be made in short steps.



The three orders of the Lever. Simple equations show the relation of Power applied to Weight lifted.

The most important of all, and there are only three on which the others are based, is the lever, but there are three possible arrangements of this, they are known as the "orders." Almost everyone knows what a lever is, it consists of a long

bar, one end held by the worker, the other pushed underneath the weight that has to be shifted. Underneath the lever, and close up to the weight, a support is placed. Now, if the worker bears his weight upon his end of the lever it will go down and the weight to be lifted will move up. The extent of this movement will depend upon the placing of the support—or Fulcrum. If it is in the middle, then the weight is lifted a distance equal to that through which the worker's pressure is applied, so no advantage is really gained. But if the fulcrum is put closer to the weight, say at a distance equal to one quarter of the length of the lever, then the pressure put on will have to be applied over a distance three times as great as that through which the weight will be lifted. In this way, an advantage is gained, for the labour of lifting is spread over three times the distance, so we have a lever that gives us an advantage of three to one. The diagram shows how this comes about, together with other placings of the fulcrum to give a variety of advantages.

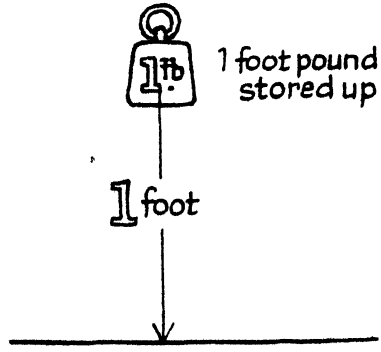
There are two other arrangements of the three points—which are the fulcrum and the points of application of the power and the load. These have been added to the drawing, and from these it can be seen that one of them—the third order—does not give a mechanical advantage at all, on the contrary it requires a stronger pull than the actual weight to be moved. To balance this, the pull has to be applied over a shorter distance than that through which the weight is moved.

The calculation of the weight that can be moved by any length of lever and placing of fulcrum can be an easy matter, and to simplify this, we have put letters on the diagrams representative of the four essential details. These have been marked in such a way that the one formula $\frac{P}{W}=\frac{l}{L}$ holds good in every case. This can be reduced to other forms of course ; thus we get $P = \frac{Wl}{L}$ and $W = \frac{PL}{l}$

There are probably still a few people about who believe that the lever will give us something for nothing, or in other words it will do more work for us than we put in. Let this be forgotten, for there is no machine, or mechanical arrangement of any sort that will give us as much in return as we put into it, nor

ever will be. It does not matter in what form the work is put in, whether it be human power or the driving energy of fuel put through some kind of engine, there is some loss, and in most cases, an appalling loss. For the simplest forms of machine worked by human power alone, the loss is due to the brake applied by nature, which we call friction, the force that comes into play when one surface is moved over another as it does with a shaft turning in a bearing.

Comparison of the work got out of the machine with the work put into it is a measure important to engineers, who call it the Mechanical Efficiency. To understand some of their expressions, it will be as well to know how work is measured. We say that to lift one pound weight through a height of one foot requires one foot-pound of work to be done. A weight of one pound suspended at a height of one foot from some solid surface, has a stored up energy amounting to one foot-

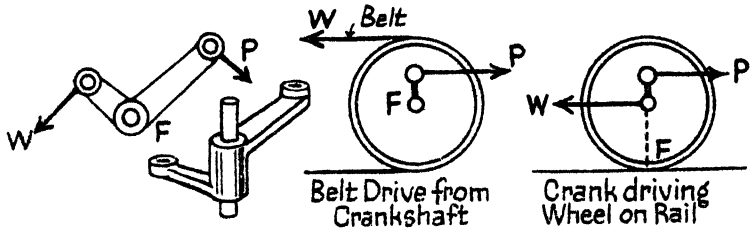


The Unit of Power is the Foot Pound (ft. lb.), this diagram shows its meaning.

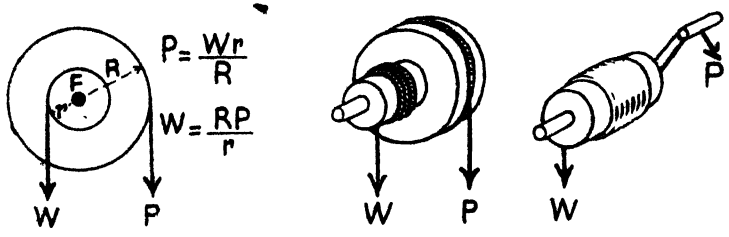
pound. That is the measure of work, but to measure power we have to introduce the unit of time, a minute. So we get the combination of one unit of work done in one unit of time.

Nearly 200 years ago, James Watt decided, after some experiment, that a good strong horse could do 33,000 foot-pounds of work in one minute, and ever since that momentous decision, the unit of power has really been the Horse Power, or the ability to do 33,000 foot pounds of work in one minute. A weight of 33,000 pounds being equal to almost 14¾ tons, some idea of the magnitude of the task can be gained.

Before we leave the subject of the lever it is necessary to mention that this device does not have to be a straight bar, for it can be bent into any form, or it may take the form of a wheel.



The Bell Crank is a Lever, developments are shown on the right.

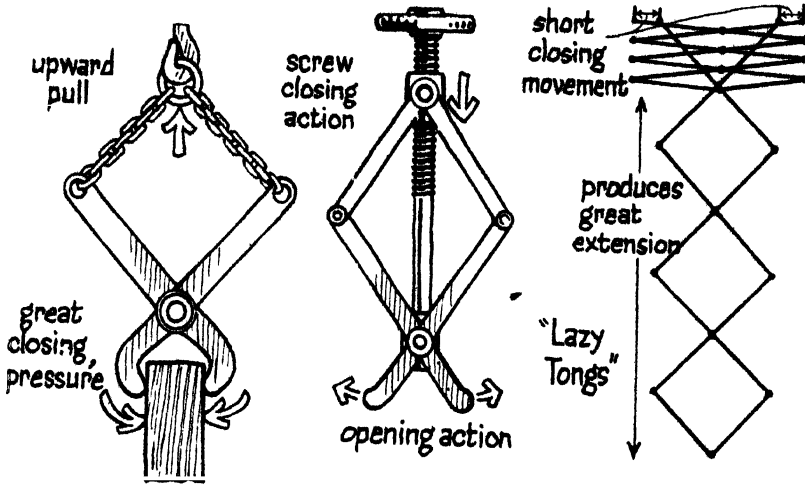


The Wheel and Axle is another ancient device. Relation of P to W is shown.

Examples of what is meant by this are illustrated. The development of this idea is the Wheel and Axle, the next device to be illustrated. Study of this arrangement will show that it is no more than a lever of the first order, giving a continuous motion around a circle, subject to the same rule as that order of lever. In the beginning this device was probably used as a windlass, such as a winding gear at a well-head, but its modern applications are considerable, as will be seen later. It is used in conjunction with the principle of gear-wheels for setting up compound trains of wheels for reduction of speed, or increase of turning effort—leverage in other words.

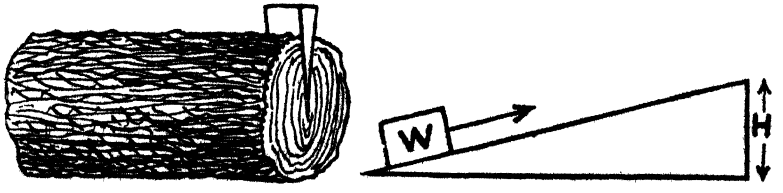
A very powerful link motion much employed in machinery is the Toggle, illustrated in two simple forms here. The simple arrangement of tongs with a closing action shows it to be a combination of levers of the first order, but the closing action of the screw gear in the second sketch is apt to confuse. The

so-called Lazy Tongs demonstrate another feature of the toggle gear when several sets are coupled together. A small closing movement produces a great extension in a direction at right angles. Conversely, a light pressure at the extending end produces a powerful action at right angles at the open end.



The Toggle is a valuable device to give powerful grip or opening action.

The Wedge must be almost as old as the lever, and its principle has a widespread application in machinery. The beautiful thing about these elementary devices is that their principles are so easily understood, and the wedge is no exception. Whether the wedge or the Inclined Plane came

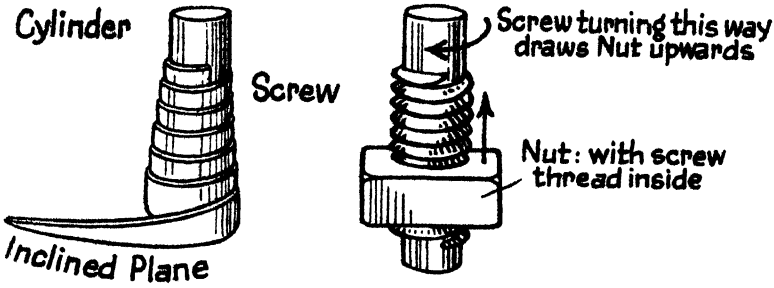


Long travel and short lift. The Wedge and the Inclined Plane, ancient engineering principles, as useful today as ever.

first could not be decided, but they are the same thing. To haul heavy loads up an artificially made hill, to get them lifted up through a height too great for lifting by other means, is a

simple idea, and it was much employed by ancient peoples in the building of their great monuments. Without doubt the Pharaohs built the Pyramids in this way.

We have gone much further with the idea, though this development is not due to us, but to the great Greek Archimedes. Winding an inclined plane round a cylindrical



The Screw is, in principle, an Inclined Plane wound around a cylindrical bar.

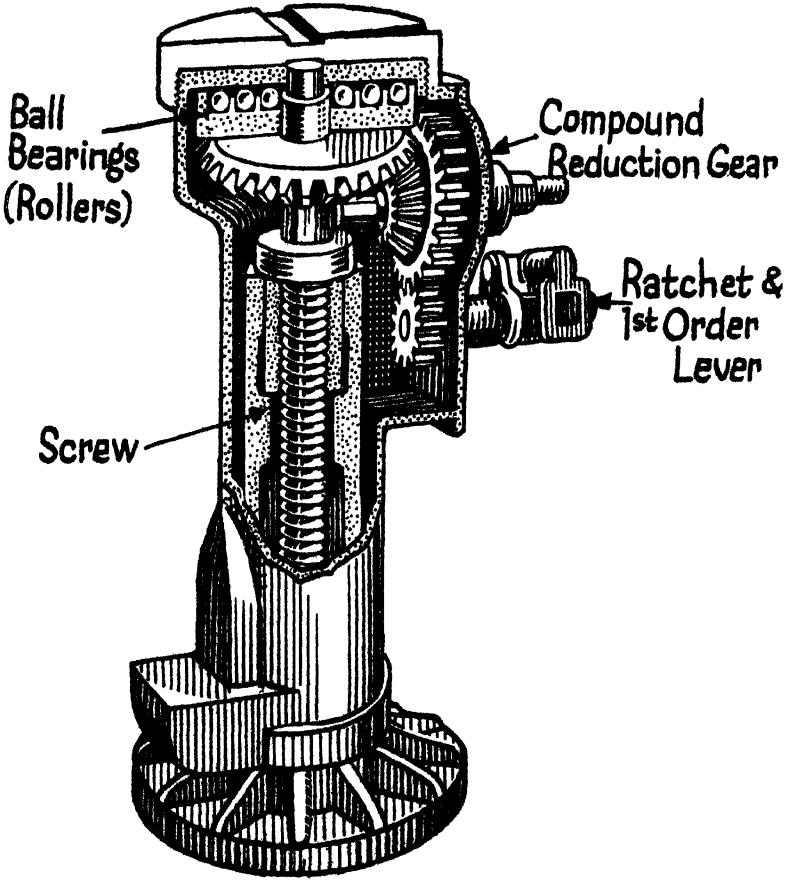
bar produces something that looks distinctly like a screw, and that is what a screw is, in effect. The sketch shows how this is done. There should be no need to remind you of the enormous use of screws in engineering, far beyond the simple application of the bolt for joining parts together with a degree of tightness and security not possible by any other means.

A sectioned drawing of a powerful screwjack capable of lifting 75 tons, reminds us, all the same, that the screw is applicable wherever great lifting power, or pressure is required.

Intricate movements of machine parts are very often made by means of a device called a Cam, which is still an inclined plane, though it is, as a rule, formed on a spindle so that its surface is curved, and not flat. Engine valves, that have to be opened and closed in a very strictly controlled sequence, are usually worked by this arrangement, and we shall recognise other applications later on.

Last amongst these elementary instruments of power, we come to the Pulley, by means of which the lifting of heavy weights is made much easier. The simplest arrangement is of a rope passing over one grooved wheel, and this merely makes for greater convenience in lifting the weight, but does not do anything to multiply the effort of the worker. By adding wheels in a certain way, and reeving the rope over them, a moderate

pull on the rope will lift a much heavier weight, but just as with the lever, the power must be exercised over a much greater distance than that through which the weight is lifted. Neglecting the waste due to friction in the pulley bearings, the ratio

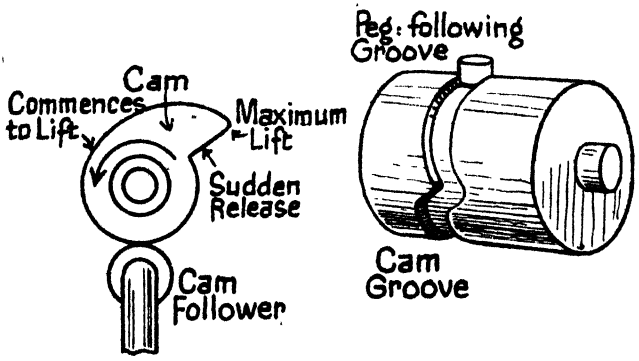


This powerful Screw Jack also incorporates reduction gears to increase the power of the lever and screw.

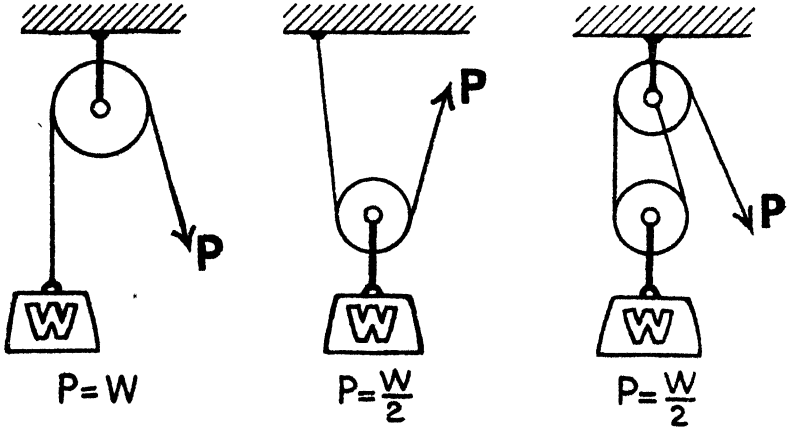
between these distances is a measure of the power of the pulley, which will tell you what weight you may expect to lift with a given pull. If you have rope and pulleys enough, almost any load in reason can be lifted, but the friction in the pulley bearings will be increased with every additional wheel, so

there is a limit to the useful application of man-power in this direction.

To calculate the power of the pulleys, it must be remembered that the fixed sheaves do not contribute anything in this direction, only the moving pulleys are to be reckoned, and each



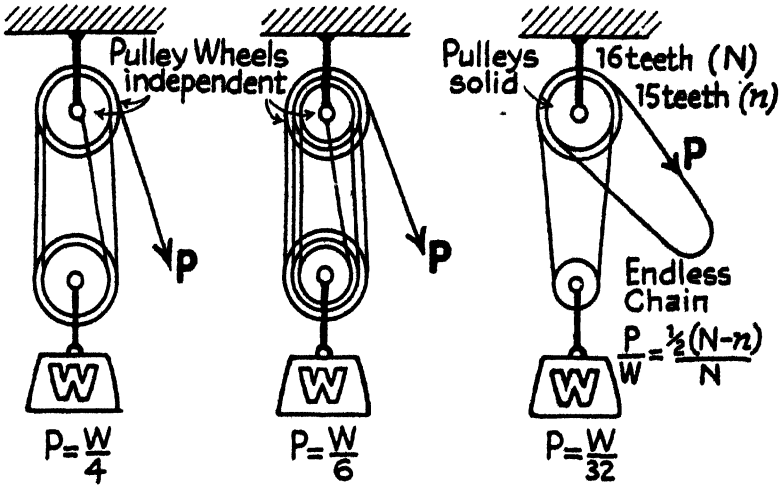
Cams are a development of the inclined plane, and are freely employed in every sort of machine.



Elementary forms of Pulley. Friction neglected, the Weight lifted (W) bears the relation to Power expended (P) as shown.

one of these halves the necessary effort. If the number of ropes coming off the moving blocks be counted, then that number represents the ratio between W and P. Our diagrams illustrate this in principle. The uses of this sort of gear are most extensive, and we shall meet pulleys many times in these pages.

There is a type of lifting tackle of great power, often used by engineers, the Weston Differential Block. Here the top block holds a pulley of two sheaves of different sizes cast in one solid piece, and an endless chain passes over them and a

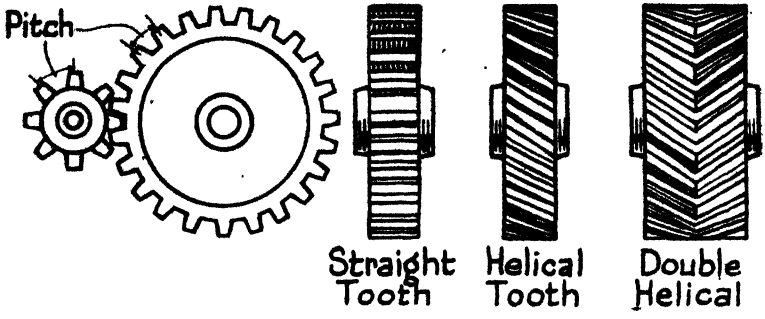


Three more pulley arrangements; The Weston Differential Block is on the right.

moving pulley below, from which the weight is hung, in the manner shown by the sketch. Slots are cast in the two upper pulleys so that the chain links positively turn them round, and a usual number is 16 to the larger and 15 to the smaller wheel. When this is so the power of the blocks is 32 to 1, the argument being that one revolution pulls off 16 links from the big wheels but it releases 15 from the small one, and the difference on one link is halved by the movable pulley below. The formula is on the sketch.

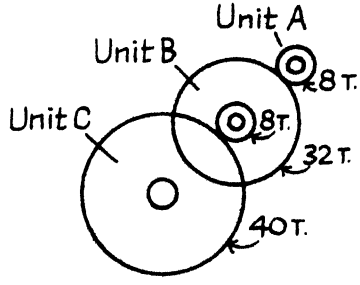
There are many other simple devices used in machinery, that are not necessarily to be considered as instruments of power. Chief amongst these must be the toothed wheels that provide for a positive non-slipping drive between axles or shafts. This is a very old invention, but it is only during the last 40 years, or even less, that the shapes of the wheel teeth have received particular attention. To reduce friction and noise, the tooth form should have a very special shape, which varies according to the type of gearing, this shape is not important to us in this

book, but it is as well to realise the necessity for it. So much friction can be cut out, and power thus saved, by well-cut gear teeth, that every machine maker maintains a special department for cutting them.



Forms of Toothed Gear in general employment.

The fact that a small gear wheel drives a larger one at a reduced speed is, of course, well known. It may not be out of place to show how to calculate the variation in speed for trains of gearing called " Compound " gears. This is shown in the diagram. It is necessary to know the number of teeth in every wheel concerned, and given this, the problem offers no difficulties.



Unit A makes 1000 r.p.m.

Unit B *makes* $\frac{8}{32} \times 1000$ r.p.m.

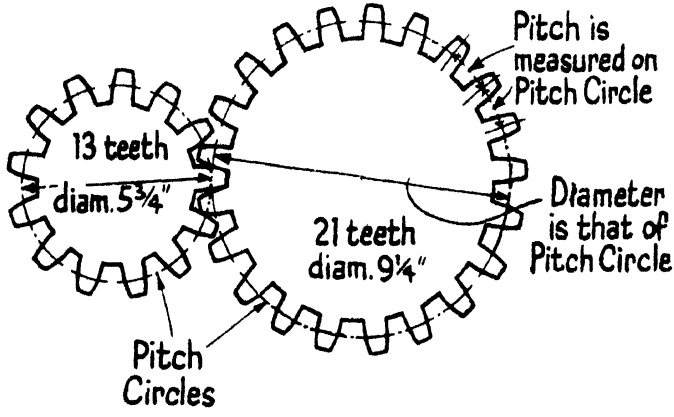
$= 250$ r.p.m.

Unit C *makes* $\frac{8}{40} \times 250$

$= 50$ r.p.m.

Elementary principle of relative speeds of toothed gears, on which all calculations are based.

There are some details about gears that are not fully realised by those who use them and may have to get worn wheels replaced, in circumstances where ready-made spares are not available. The Pitch and number of teeth are the two essential things to know about any gear-wheel, but though anyone can count the number of teeth, not everyone knows *where* to measure the actual pitch. This is shown on the diagram,



$$\text{Diametral Pitch} = \frac{\text{Diameter (ins.)}}{\text{No. of Teeth}} \qquad \text{Circular Pitch} = \frac{3{\cdot}1416 \times \text{Diam.}}{\text{No. of Teeth}}$$

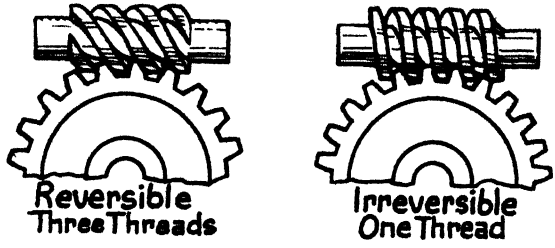
Details that should be understood by all users of toothed gears.

whereon are also shown other essential details. All measurements, as can be seen, refer to the Pitch Circle, midway between top and bottom of teeth. Specification of a gear is actually complete if number of teeth and diametral pitch are mentioned.

That there are other forms of gear teeth than the customary straight type is of course well known, but why there should be is perhaps not so clear. Bevel gears, worm gears also we understand the need for, but the helical gear seems superfluous until it is realised that its teeth roll and not slide upon each other, and in consequence a given wheel will carry a much greater load than the same size with straight teeth. Smaller pinions can also be employed. The only disadvantage is that helical teeth set up an end thrust. With big loads two helical gears are cut on the same wheel in " herringbone " form and these neutralise each other's end thrust. Well-cut helical gears

run very silently, and are largely used in enclosed gear boxes and similar places.

A positive drive can also be obtained by means of worm gears, these are of two sorts, reversible and irreversible, that is to say, according to the nature of the worm thread. If this is a quick start type, it will be reversible, that is to say, the worm wheel will drive the worm freely. Motorcar back axles are of



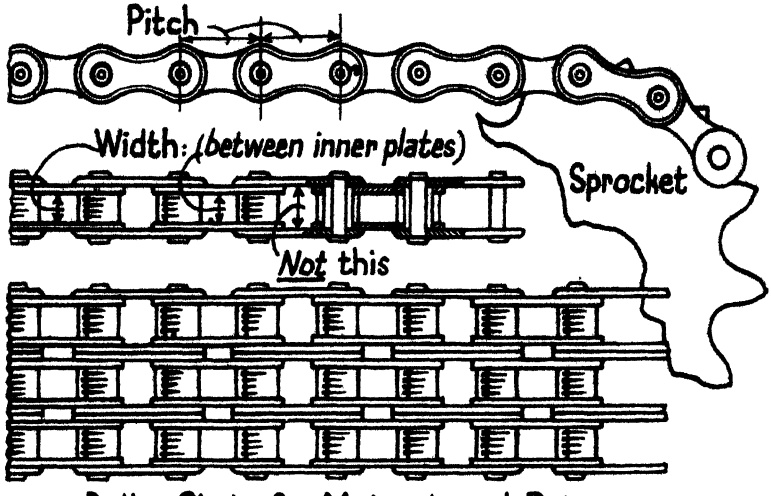
Worm Gears : the worm can be driven by the wheel if the pitch is long, as with two- or three-start threads. Single worms (right) are not reversible.

this sort. But a slow thread will not be reversible, and it will only drive the wheel slowly. Both these sorts are shown in the sketches.

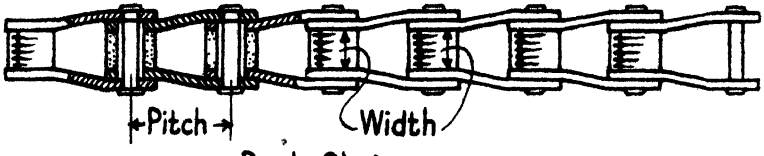
Gear wheels connecting shafts at right angles can be either bevel, or spiral, according to circumstances, in addition to the worm drive.

Chains are used for positive driving now to a much greater extent, and so well made are they that the efficiency they offer is remarkable, especially where it is possible to run them in oil. Various types of chains have been tried, but the choice has now narrowed down almost entirely to one almost exactly similar to the well-tried bicycle chain. The main difference is that they are made up in multiple form, two, three or four alongside, each having its sprocket wheels on which to run. The huge chains for bucket excavators are similar in principle to this.

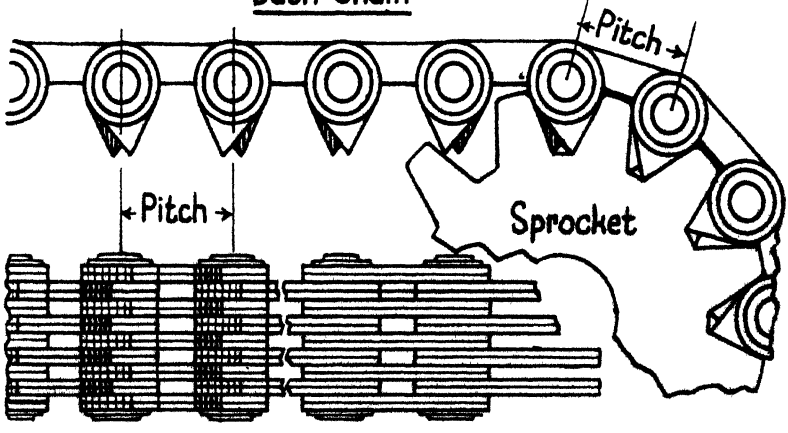
Three principal types of chains are illustrated, the first two are roller chains and the other is of a totally different sort in which teeth are formed on the under, or driving side to engage with the teeth on the sprockets. The latter sort are not employed in the open air, so to speak, as the roller chains are. Inverted tooth chains must be adequately lubricated always, and as this



Roller Chain for Multi-strand Drive



Bush Chain



Inverted Tooth, or Silent Chain

Various types of Chain Drive, with indications of the method of measuring Pitch and Width.

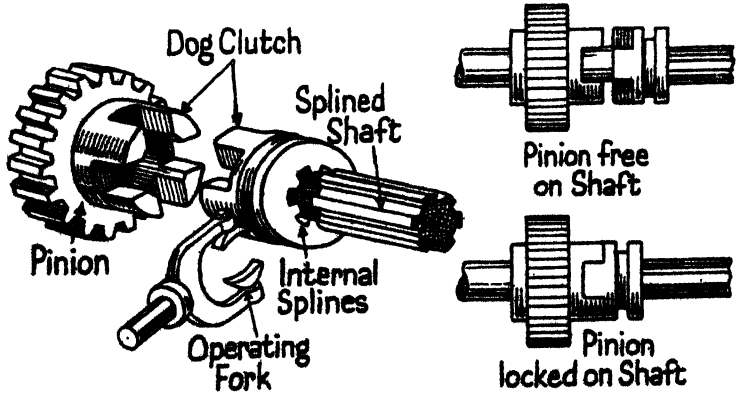
desirable state can rarely be achieved by the naked chain, their work is usually confined to driving camshafts and the usual engine auxiliaries in power units.

So long as the sprockets on which chains run are in perfect alignment, they will give excellent service, provided they can have an occasional cleaning in paraffin and a good oiling from time to time. As a rule, in good design, the chain is loaded only up to about 5 per cent. of its breaking load, so breakages are rare. Failure comes from gradual stretching so that they are out of pitch, and it should be noted that it is little use tightening up the slack after a certain degree of stretch has been reached.

The pitch of the chain is clearly marked on the drawing and can easily be measured if it is not known for certain. The width is measured *inside* the inner plates, or if the chain is lost, then the width of the sprocket tooth gives this information.

Amongst the toughest jobs that chains are called upon to do in more or less out of the way places are those in crawler drives for excavators, where they can often not be seen at all for the muck that covers them entirely. This is where a little service does a lot of good.

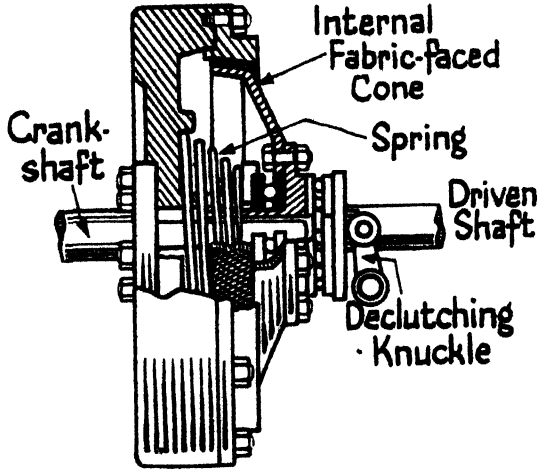
Clutches, to connect or disconnect driving shafts from driven ones, are an essential item in the make-up of machines such as



The Dog Clutch is a positive type, and the splined shaft permits sliding gears on a shaft.

those with which we have to deal. These are of two main sorts, positive and slipping. A simple dog-clutch, giving a

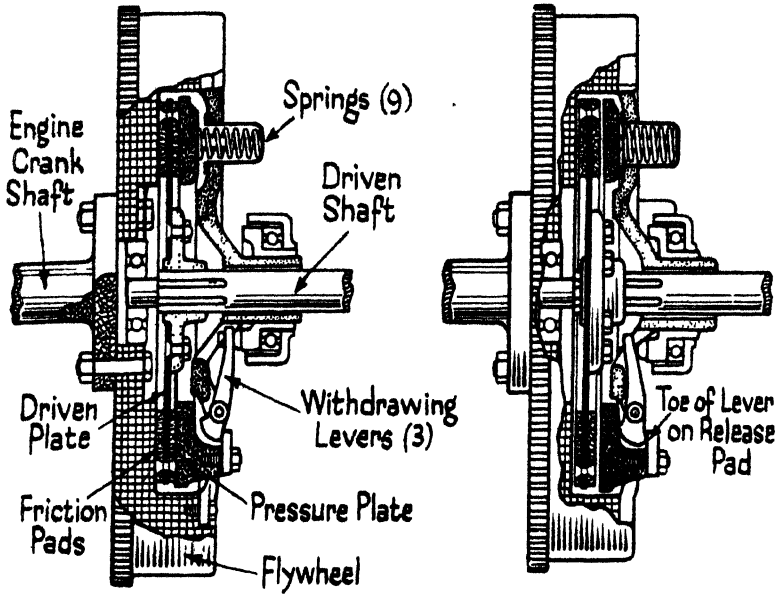
solid drive or no drive at all, is suitable in some cases, but it can only be used where the shafts can be brought to a stop, or almost a stop, before the dogs are engaged. Where this cannot be done, a clutch that will slip in taking up the drive must be used, and these are most frequently met with where the shaft of an engine has to be coupled to the load. The motorcar provides a well-known example of this sort of clutch.



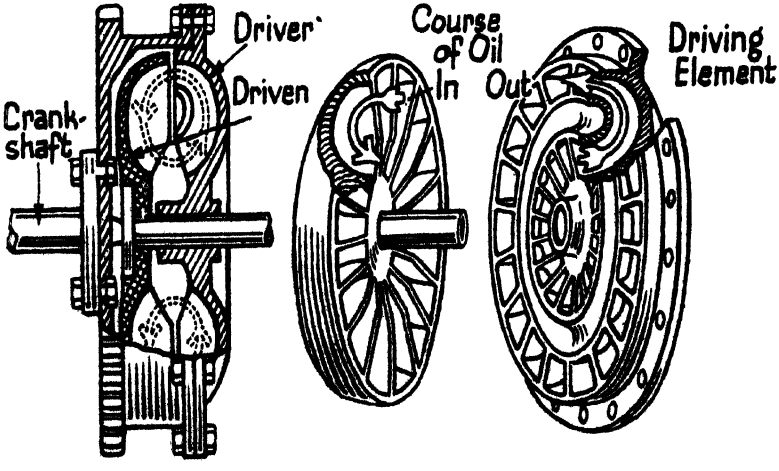
A well-tried form of Cone Clutch, with internal spring. This type will not admit of much slipping.

There are several types of slipping clutch, from the simple cone-faced sort, to the single and multiple plate varieties. They do not differ greatly from the motorcar clutches, and examples are illustrated here.

At least three excavator engines we know of are coupled to their work through an oil clutch in which there is no definite contact between driver and driven units. Both are enclosed in an oil-tight casing filled with oil, and the two elements are formed with paddles on them so shaped as to set up a very strong flow of oil. Those on the driver throw the oil at cups on the driven unit and there is little clearance between them, so the latter portion is compelled to rotate under the pressure. With the engine idling there is no drive at all, but when it is speeded up, the drive takes up very gently and at full speed the slip is of the order of less than one per cent. The drive is very



A very useful type of Clutch. A single fabric surfaced plate is the driven member, clamped between the pressure plate and the flywheel inner face by nine springs. The disengaged position is shown on the right.



The Hydraulic Clutch, generally known as the Fluid Flywheel. This type can be slipped indefinitely.

sweet and admits of continuous slipping and calls for no pedals, levers, springs or other gear. A diagram of the action is appended, the actual form of the elements is somewhat complicated.

More elaborate systems of power transmission use oil under pressure, the Hele-Shaw Beacham gear can be quoted as an example, but these are not often to be seen in the robust type of contractors' machinery.

The work of the contractor being almost entirely in the field, it is necessary that his machines should be quite independent of outside sources of power, and that each one should therefore have its own driving engine. This is easily arranged for most of the items of equipment, so we find that petrol and heavy oil engines are found everywhere. Steam is used to a diminishing extent. Liquid fuels are so much more convenient to use, and the steam boiler is reckoned, at best, a tiresome affair taking up space that can be usefully saved, and, in addition, requiring constant attention. On the other hand, the oil or petrol engine starts up at once and keeps running continuously without any attention whatever. For some machines, such as pile-driving hammers, steam is used, and so a boiler has to be provided. The working of these will be dealt with in due course, but for the principles of the internal combustion types of engines—as well as steam engines—we would refer our readers to more specialised books on this particular subject.

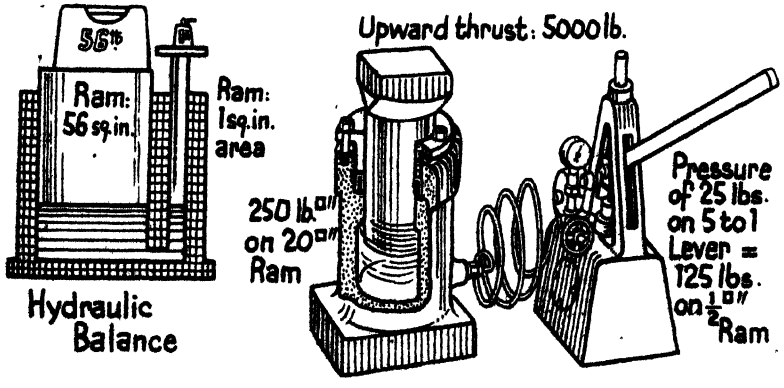
Where electricity is wanted, portable generators are provided, driven by oil or petrol, but in some circumstances local supplies can be drawn upon, though almost invariably this has to be converted to direct current. Apart from the necessary light, electricity is needed largely for welding in the field, and numerous portable appliances can be used conveniently at a distance from the generating set where electric power is to be had.

Compressed air provides an invaluable aid in the same way, and portable compressors form an indispensable addition to the contractor's battery of tools. Most people will be acquainted with the noisy—but fascinating—implements used for breaking up old concrete, these are driven entirely by compressed air, but we shall deal with other tools that need abundant supplies. A portable compressor of average size will have an internal combustion engine of about 30 horse power coupled direct to a two cylinder compressor, able to

deliver 130 cubic feet of free air, at a pressure of 100 lbs. to the square inch, every minute continuously. Air is stored in a reservoir provided on the set and when this is full at the maximum pressure, a control valve passes some to a governor on the driving engine. This closes the throttle, to cut down the engine speed to a mere tick-over, until the pressure in the reservoirs falls below the proper figure, when the reverse process takes place and the engine speeds up again.

Free air is, of course, uncompressed air, so the expression "130 cubic feet of free air," means that the compressor draws in that quantity of air from the atmosphere every minute. A great deal more about compressed air will be found on a later page, together with details of the working of the tools.

Mention must also be made of the main principle of hydraulics. This provides a valuable method of transmitting pressures that can be used in a variety of ways. Water is practically incompressible, but it can be put under enormous pressure by means of a pump and stored in a cylinder under load. This pump will have a ram of small size, connected by a pipe to the large cylinder of the hydraulic press. If the area



The Hydraulic Balance (left) provides the principle for the Hydraulic Jack (right).

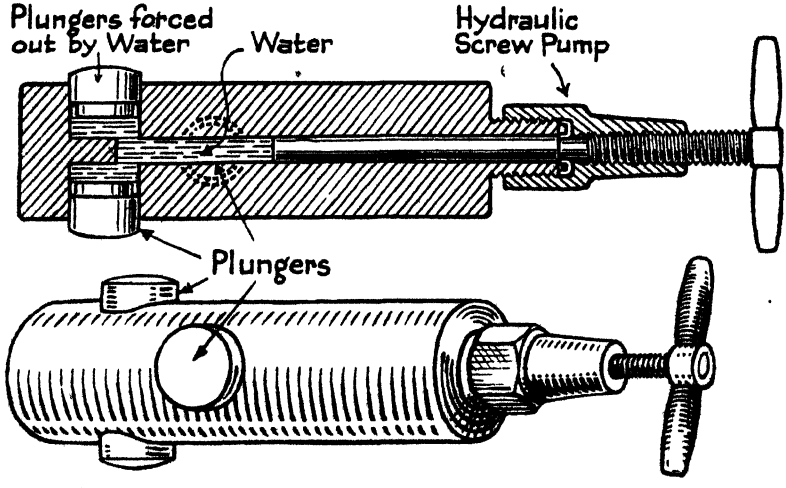
of the pump ram is one square inch, and that of the press cylinder is one hundred square inches, than a weight of only 5 lbs. on the pump ram will balance a weight of 500 lbs. on the press. The pressure of the water in the closed system is 5 lbs.

to the square inch, and the larger the piston on which this acts, the heavier the weight it will lift.

This sounds remarkable, until you find that a down stroke of the pump ram of 10 inches will only lift the big piston by one tenth of an inch; that is where the difference appears. Pressures in hydraulics rise as high as 1,500 lbs. to the square inch, and with motor-driven pumps a large quantity of water can be put through, so that a rapid movement of the big piston is made.

For work in the field, small portable outfits are required, and these are usually made with hand pumps. The rams of these pumps are quite small, so that each stroke delivers only a very small quantity of water under pressure. Hydraulic jacks for lifting heavy weights, or applying pressures in various ways, will be seen often enough, they conveniently provide power that would be difficult to get in any other way in such compact form.

There is a very useful device known as the Hydraulic Cartridge, an implement of immense destructive power that

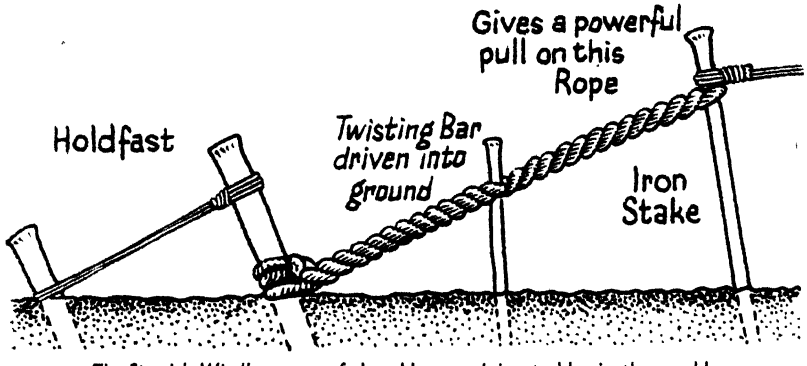


The Hydraulic Cartridge is used to break up old concrete silently.

was much used in the silent demolition of old Waterloo Bridge. It consists of a short length of four inch steel with a hole bored into it, machined for a plunger pressed forward by a screw. Side passages open into the central one, each having a steel

plunger 2½ inches diameter with hydraulic cup leather to seal it. The plungers are flush with the surface to begin with, and the cartridge is then inserted into the four inch hole prepared for it in the material for demolition. The tool is filled with water and the screw plunger screwed in. This traps the water, and the screw handle being turned continuously, the pressure may rise even to 1,000 lbs. per square inch, with the result that the side plungers are forced outwards with an irresistible effect. This is an outstanding example of the sort of ingenious application of mechanical and physical principles that is so often met with in this branch of engineering. The work it does is equal to blasting with explosive, and as already mentioned, it has the quality of silence with a degree of safety that cannot be approached by blasting.

Lastly, because we have mentioned it in the text elsewhere, here is an illustration of the so-called Spanish Windlass. Everyone knows this valuable addition to the equipment in the



The Spanish Windlass, one of the oldest straining tackles in the world.

field, for putting on that extra bit of screw when it is wanted and all the other gear for straining is fully occupied. Nobody knows how the Spaniards got credit for it, the Ancient Egyptians used it to strengthen the backbones of their Nile ships as far back as 2600 B.C. Not that that matters much to us, the thing is to remember it when it is wanted, so often the writer has seen people scurrying round for screw tackle where a couple of fathoms of rope and a light crowbar were all that was really needed—only they had forgotten !

Chapter 2

THE PLANT ENGINEER.

A BOOK about contractors' tools could be very like a catalogue, and even the best of catalogues is apt to become wearisome after a while, even to the greatest enthusiast. So this book is about the machinery and tools that might be required in the construction of a layout of docks and factories. It will also deal with some of the real things that happen in the field, because it must not be imagined that everything runs smoothly all the time, in spite of what the catalogues say. So often the man out on the job runs up against a set of circumstances that has never occurred to him before, and maybe to nobody else either. He has got to set up machinery in ways that are not laid down in the book, and that would have horrified him to think of 24 hours previously.

He has got to be a man of infinite resource, not to be deterred by anything at all. When the inside stories of the war can be told—as they often are privately—some extraordinary episodes, as heroic in their way as anything done on the field of battle will come to light. Many of these are known to the writer, but in no case did the men who played their part in them achieve any fame whatever, indeed, no such thing would occur to them. At the most, there would be a satisfaction in work properly done against impossible odds, or seemingly impossible, for these things are always seen through ; more usually there is an adequately expressed and lurid thankfulness that the old so-and-so will be all right now ! To get the great labour-saving machines on to the job is often a huge task that has to

be performed by hand, though the introduction of the Bulldozer has disposed of much of that.

The engineer's first view of the site is often a most depressing affair. A desolate stretch of sea-coast, miles from anywhere, two or three miles from the main road and five or more from the nearest railway, and even there he has no facilities for unloading heavy stuff. Talk about starting from scratch! He has some feelings about the artist who drew the perspective view of the finished scheme, with its roads, railways, sidings, wharves and warehouses. He finds it hard to believe that that particular gentleman—though he does not think of him as that—ever saw the site other than in his mind's eye from an ordnance map. Yet he knows that it will come right, that in a year's time the whole job will be virtually finished, and as that is the case, he can set to at once, cutting out all the soliloquising. It is quite probable that there is a penalty clause in the contract, too, imposing fines for every month's delay in completion.

He has seen it all before, though this may be the biggest yet. But we run on a little too fast, for there is much that has to be done before we get to this stage.

It is easy to think of the sort of work we have in mind here. They are always in hand, all over the world, for governments or for one or other of the many large combine companies controlling the basic industries of the modern world. The war has called for many such works, and the dreadful devastation caused will call for the reconstruction on improved lines of hundreds of others. So for the engineers there will be plenty to do for a very long time to come.

We will imagine then that a big manufacturing concern has decided to set up a new works, and has, after much searching, discovered a suitable site on the sea-coast. A harbour where ocean-going ships can be accommodated has to be constructed, and the most modern handling machinery installed for unloading.

Consulting engineers, accustomed to the work, draw up the plans, estimate the approximate cost, and then after making alterations in the scheme to suit their clients, prepare sets of drawings with detailed descriptions of all the work that has to be done to transform a bare waterside into a hive of industry.

These preparations being duly completed, the next step will

be to find somebody to carry out the job. This somebody is the Public Works Contractor, and it is his responsibility to take over the entire work of construction, providing all the tools, machinery, gear and materials that will be wanted. Moreover, he will have to do it under the continual supervision and the eagle eyes of the consulting engineers' representatives, who will see to it that no slipshod work gets by, and that all materials are up to the strict standards specified on the drawings. There are several first-class firms in this country fully able to take on the most elaborate schemes in any part of the world, and it is safe to say that there is a British firm of contractors at work somewhere abroad always.

It never happens—except perhaps in war time—that a contractor is offered a job without having to face the competitive quotations of several rivals. He will have to put in a keen estimate of his costs in any case. The usual procedure is to invite about half a dozen firms to tender for the job, and to each of those who can take it on, a complete set of the drawings and specifications will be sent.

Armed with these, the competitors' staffs of estimators and engineers visit the site so as to learn as much about the local conditions as they can. Using their past experience they work out the cost of every item of material, of every hour of labour that will be needed. Having added it all up, they allow for a profit of perhaps six per cent., and are then ready to submit their price for the contract. The tenders, which are all in sealed envelopes, are all opened at the same time on some prearranged date, and provided the contractor is a well-known and reliable concern, the lowest tender will, in all probability, get the work.

It all sounds very easy, but when the contract runs into millions of pounds, as many do, a very little slip in the calculations might result in the loss of many thousands of pounds. In a contract, say, for a £4,000,000 work there might be a difference of fifty or sixty thousand pounds between the highest and the lowest tenders. So the lowest bidder has to be sure that he is clever enough to manage a job that has been valued higher by equally clever and experienced contractors.

One way and another the contractor's staff get many a headache worrying over the many problems, and the chief mechanical engineer considers that he has an unduly big share

of them in deciding what machines to put on to the job. Not only that, but where he is going to get many of them, for it is out of the question to buy entirely new gear.

As an example, the works we are considering will certainly need a number of cranes to handle the material, and a variety of cranes at that. What sorts will be best here ? Shall they be electrically driven or steam ? Is coal to be obtained easily and cheaply, or will it be better to have diesel-engined cranes ? Will it pay to put down a temporary electric power station and make our own current, or can we get an adequate supply at reasonable cost from the Grid ?

These, and a hundred other questions of a similar nature must be answered, and answered accurately. A mistake may well mean the failure of the whole scheme and no one is more worried at this point than the contractor's plant engineer. If he sends a whole lot of unsuitable gear down to the site, it will have to be taken away again and replaced, at considerable expense for transport, the first bite into the estimated profits. Be sure he will have to explain his mistake to the board of directors ; if he makes such a simple one at this stage he is not yet very experienced.

The contractors have plant yards with well equipped repair depots where they keep such machines as are not in actual use on some other contract, or out on hire to some other firm, and the true plant engineer knows his machines better than some people know their own families. He knows their weaknesses, their age ; he knows what they will do and what is more, exactly what they will *not* do. He remembers the patch that was welded on the jib of that old navvy, and the pegged teeth in the gears of that stone crusher they bought second-hand from so-and-so five years ago. Many a lurid story he can tell of circumstances that occasioned the repairs to machines that he must always bear in mind, because those repairs may well have reduced the working efficiency. A trifle of overload for but a moment and away goes the lot. Not only must he remember it, but he must impress it upon the men who are to drive it.

Again, when one of his directors reminds him of a number of electric motors they have in the stores, it is he who must remember that they are direct current machines, which will not

suit the alternating current that they have decided to take from the Grid supply.

At last most of the problems are solved, and the search begins for the necessary plant that is needed to make up the requirements. Some will certainly have to be bought new, and some can be found in the second-hand market, genuine bargains if in good condition, but a heart-breaking poor sort of bargain if it has been patched up to catch an unwary buyer. After a few years at it, the chief is pretty well up to all the catches, and he will tackle this business with confidence in his ability to spot the likely snags.

Here is an example of the sort of thing involved. Let us imagine that it has been decided to put in four really big derrick cranes, one of which is shown in the drawing on page 72. It has a jib nearly one hundred feet long, capable of lifting about five tons. An advertisement in the Contract Journal tells of just such a crane for sale, so off goes the plant engineer, possibly to the far north, or to some out-of-the-way place in the west country, to inspect the machine.

Derrick cranes work on tall gantries with three legs ingeniously built up from lengths of stout timber, that can be extended in height from time to time as the job demands. Our engineer arrives in due course alongside his prospective purchase. Climbing out of his car, he puts on his overalls and commences to swarm up the timbers of the gantry.

Arrived at the top he stops for a breather, and digging his knife into some of the timbers, discovers that they are half rotten. By the time it is taken down and re-erected, the gantry, which may well have cost a couple of hundred pounds, will be good for nothing better than firewood. Making a mental note to the effect that he will buy, less the gantry, he climbs along the struts to the front of the driver's cab.

The first thing he wants to find is the maker's name plate, for some makers have a good name where cranes are concerned —as with everything else, of course. This is usually found inside the upright central leg, called the king-post. To get at this plate means getting inside the driver's cab, which is quite certainly nailed up against the wind, so he has to wriggle through between the bottom of the jib and the rope drums. As the ropes are kept well oiled, this process will be bad for his overalls, but when after much searching he finds the plate, he

decides the effort was worth while, because it is a make he knows well. The number on it shows the crane to be not much more than two years old, something else in its favour.

The derrick crane is more fully described on page 71. From this it can be seen that the king-post turns on a pivot, a bearing that fits over a large pin, the king pin, which is secured solidly in the centre of a large gear ring—the slewing gear. Meshing with this gear ring is a small pinion carried on a vertical shaft projecting below the cab. Every tooth in pinion and ring must be examined, but a practised eye can take in their condition almost at a glance, so the engineer passes on to the gears that do the hoisting of the load.

There are three motions, slewing or turning, luffing, and hoisting, and an electric crane will have a separate motor for each operation, each with its own controller. Also there are powerful brakes of the band type that can be applied to each of the three motions, these have to be carefully examined to make sure that the frictional material and drum surfaces are in reasonably good order.

It often happens that where a crane has been standing idle for a long time the current will be cut off, so the motors cannot be tested. So the engineer, if he is wise, will buy the crane subject to the motors passing the usual electrical tests. In these tests a heavy pressure, or voltage, is passed through the windings and measurements taken with a meter between windings and earth. If the insulation is good the resistance will be very high, but if any fault is there, the leakage will be immediately shown up.

Satisfied with brakes and gears, the engineer now climbs up into the roof of the cab, wriggles out through the stays of the mast and climbs slowly to the top. If he has a weak head, now is the time to keep looking up ! One look down, even if for only a second, and he may lose his nerve, for by now he may well be 150 feet above the ground.

There are several important things to look at up at the top, first of which are the bearings of the rope pulleys, so he must carry on. Of all contractors' tools, the derrick crane is the most likely to be the cause of a fatal accident. A plant engineer could sit down and tell you the name of every split pin, keep pin and securing device, with its shape and position.

All the time he is inspecting a derrick, and the whole time he is erecting one he goes over and over these danger points in his mind's eye, assuring himself that he has missed none of them. A small detail missing may mean all the difference between safety and a man's death.

Still higher up the mast and he reaches the very top where he finds another steel pivot pin, which enables it to turn. Also there is the pulley taking the hoisting—or burden—rope. Once he is satisfied with the condition of all these, he can really begin to make up his mind that the derrick is a good one, and his practical knowledge of what these things cost will guide him in the matter of the price that will be justified. This part of the business is none of our concern, so we will leave it at that, just one example of the daily routine tasks of the plant engineer in getting a good start on the new contract. Many others will be dealt with in the same way.

Before we leave this subject, one more example that has come to our notice seems well worth the quoting, just to show something of the possible routine work that the plant engineer may have to face, and tackle out of his own store of knowledge.

Suction dredgers are, in some circumstances, most valuable items of equipment. Fitted with a powerful centrifugal pump, able to handle mud, stones and shingle as well as water, it can discharge these on the adjoining banks to a distance of several hundred yards if need be. Sea walls can be built thus, or a mass of material can be poured in behind a line of steel piling erected for dock or similar work.

The discharge pipe from the pump passes up through the deck to another elbow to which is connected a line of steel pipes supported in the water by floats or empty barrels. The dredger having no propeller, is at the mercy of wind and tide, except for wire ropes attached to winches and anchored conveniently. It can thus prowl about slowly, but trouble can be waiting round the corner.

Maybe as the tide recedes, some of the floats get stuck high and dry, with the result that the weight of pipe line comes on one joint. Away this goes, and the crew have to set out for a pipe-fishing expedition, pleasant enough on a summer day, but not much fun on a cold night in a howling gale. Sometimes the warping cables snap, and away goes the dredge with the

crew helpless to do anything until she fetches up on a mud bank from which only hours of hard work will free her.

Just exactly this eventuality befel the dredger concerned in this incident. It was blown ashore in a gale on a spring tide down by the sea. Every one knows that a spring tide is just so much higher than the normal, so this machine was left nicely above the regular high tide line. However, it was required on a riverside job about a hundred miles away, so it had to be relaunched somehow.

The bottom was quite fast, and the total weight about 70 tons, so any idea of pulling it straight off the beach had to be abandoned, even had any tugs sufficiently powerful been available. Attempts were made to push it by building a timber revetment as a support for jacks set with their noses against the hull. These jacks were hydraulic, six of them, each able to lift 35 tons, but though the men worked at them till the handles bent, the hull showed not the slightest sign of budging. So the engineer had to sit down and indulge in some hard thinking.

A stack of 40 foot steel piles left over from the sea-walling job gave him an idea. Hurrying off to the nearest blacksmith, he helped to make a steel bar, twenty feet long with a stout eye at each end. This was driven under the hull at the stern end, until one eye showed on the far side. A length of wire rope hitched to this, and a rope from a winch to the other, a few minutes work with the winch brought the eye bar out, and a series of timber lengths were pulled through in succession. The hole being now large enough, one of the piles was pulled in so that the hull rested on it nicely.

This operation was repeated six times until the hull was lying on six flat steel slides ; well smeared with grease, they formed a splendid slipway, over which the jacks easily pushed the dredger back to its proper element in a few hours. Here it was taken in tow by a motor-launch, which led it out to a sea-going tug, and this took it round the coast to a sea-port where a massive crane was available.

The next part of the work was quickly accomplished, consisting merely of lifting it from the dock and depositing it on to a motor-drawn trailer. Two days later it was set down in its new home, a flooded gravel pit near London.

Simple ? Well, yes, when you know how, but not exactly academic engineering, of course. The steel piles saved the day, though nobody else thought of them, and our friend was called in where others had given up the task as hopeless.

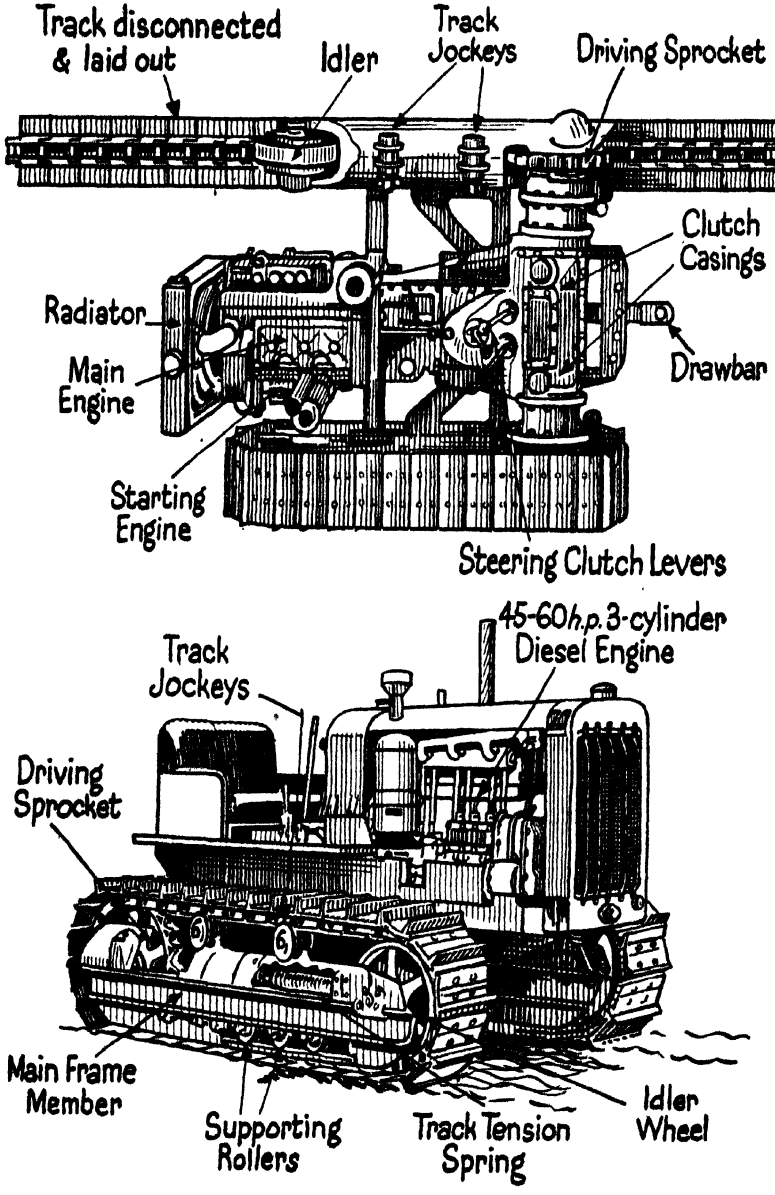
Chapter 3

LEVELLING THE SITE.

It is not often that the contractor can make a clear start on a job without a good deal of preliminary levelling and squaring up, involving some heavy work. More especially is this so when aerodromes have to be laid out covering a variety of country that looks most unsuitable at first sight. Even here in the British Isles the problems can be considerable but when the work has to be done in country that is covered with dense scrub and even jungle described as impenetrable, it is obvious that ordinary methods are worse than useless. Every man who has had to work in such places knows that the vegetation will cover up his tracks in a few days unless it is most thoroughly rooted out, in a way that is, to say the least of it, discouraging.

Recent years have brought us experience in this sort of work, and desperate necessity has brought out machinery of the most massively powerful description, able to cope with anything so far met in the wildest jungle. It would seem that nothing can stand in the way of the Bulldozer and its group of site-clearing machines, and the public has been told often enough about their work, though few people have seen one or have any idea as to what they are like.

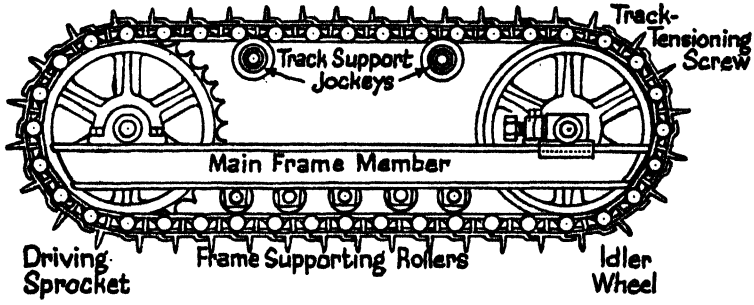
Quite obviously, if we are to be able to drive a machine steadily forward across ground of a rough sort, digging out trees, scrub, rock and who knows what besides, then some sort of extra powerful tractor must be available. Wheels of the old sort will not do. Fortunately this is to hand in the group of machines known as Tracklayers, often referred to as caterpillars. This is incorrect, as the title is one registered by the



Capable of tremendous hauling, *Tracklayers*, represented here by the Holt Caterpillar, work best in difficult circumstances.

American Holt Company for their tracklaying tractors, and strictly speaking should not be used to describe any of the others. There are at least six makes of these machines available. They differ of course in detail, but as the general principle is the same, we have selected the true Caterpillar to represent all of them. The author's first experience with them was made in their very early days, during the 1914-18 War, where they were provided for the haulage of heavy howitzer artillery. The tracklaying principle is employed to a considerable extent apart from its use for tractors, and other examples will be met with in due course. An examination of it is justified here.

Briefly, it consists of a framework carrying an engine, driving an axle with heavy sprockets at its outer ends, this axle being at the rear end of the machine. At the front end is a pair of wheels of the same size as the sprockets, but without teeth ; these are the idler wheels. Passing over these wheels, and stretched between them, are belts made up of heavy steel plates flexibly linked together, these form the tread of the machine on the ground. The undersides of the belt link plates are formed with slots into which the sprocket teeth engage, and also a level surface on which rollers can run. This makes a track for the small rollers fitted at the bottom of the engine framework, and above these are two or more rollers that



The elements of the Caterpillar Track.

support the weight of the track, checking the tendency to sag unduly. A drawing shows the details of this gear.

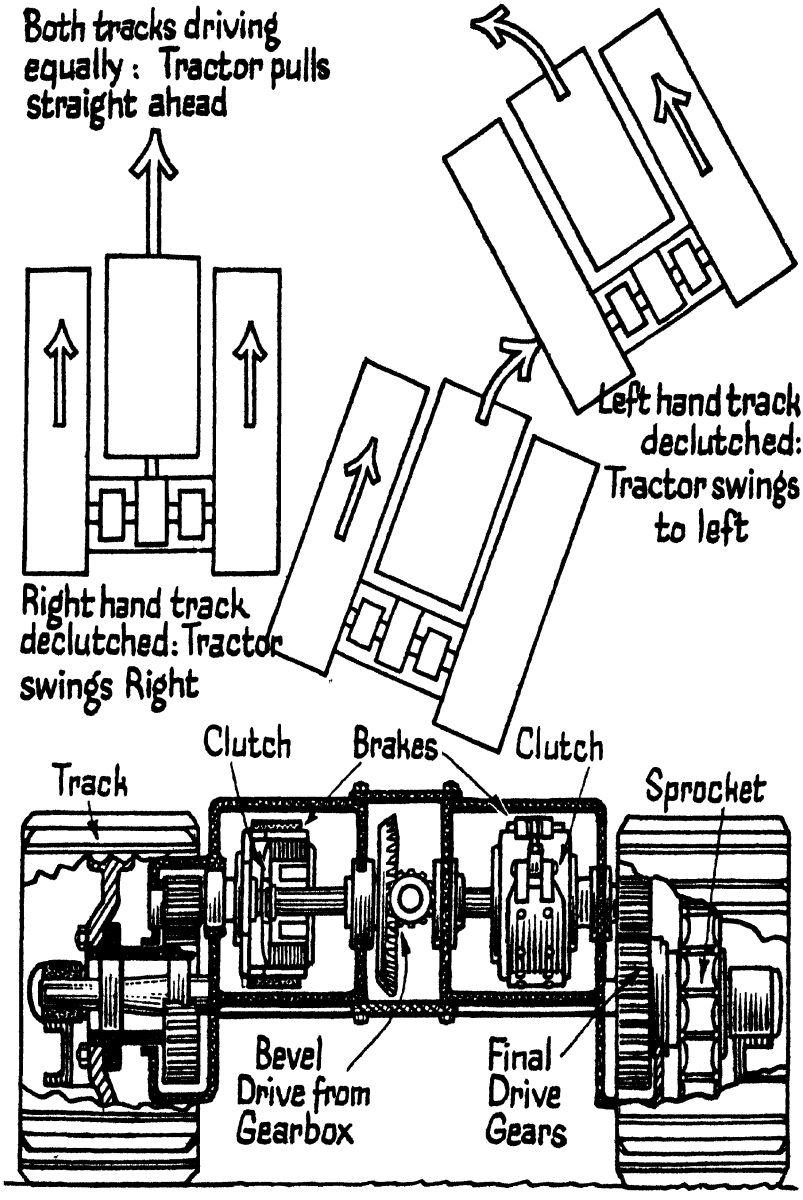
The belts are made up with various sorts of plates, according to the work the tractor will be called upon to do, but one for the sort of tasks we have in mind here will certainly have up-

standing ridges formed across the link plates, the purpose of which are quite easy to understand. These are shown in the drawings. Where the ground is of a hard, unyielding nature, these links will be without the ridges, presenting a smooth surface to the ground but yet offering an adequate grip. Even the softest soil can be crossed easily by a caterpillar, where a man's foot will sink deeply at every step, for in spite of a weight of anything up to 14½ tons, the pressure on the ground is less than that on the sole of a man's boot. A few figures will soon demonstrate the truth of this statement.

The foot of the average man will press on the ground to the extent of about 7 or 8 lbs. per square inch when standing, and this increases to 12 lbs. momentarily when walking, more still probably when running. A motor-lorry wheel with heavy tyres will press on the road to the amount of 100 lbs. per square inch, at the least estimate, but the broad tread of the heaviest track-laying vehicle will not much exceed 6 lbs. per square inch. At the moment we believe the heaviest Holt tractor on the list scales the 14½ tons just mentioned, and its track shoes are 20 inches wide.

There is a provision for tightening the track, a screw adjustment to the idler wheels. The enquirer will doubtless wonder how steering is effected, there being no obvious method visible from outside. This is quite a simple matter in actual fact; the driving axle is in two parts, with clutches to connect it to the track sprockets. With both clutches engaged, the tractor goes straight ahead, but with the left hand clutch disengaged it swings to the left, and this is a very quick turn indeed if the brake is applied also. In the opposite manner, a swing to the right results from disengaging the right hand clutch. Two levers are provided for this, but it is not necessary to disengage either clutch fully, slipping is permitted, so slight changes of course can be made.

Mention of power brings us to the engine. It is of course an internal combustion machine, either petrol or compression ignition, usually, but incorrectly called diesel. The preference of most builders is for the latter, largely due to the cheapness of the fuel it uses, and also to its extraordinary power of hanging on when a petrol engine would stall. The type has one disadvantage in its very high compression, which makes it impossible to start by hand, consequently some very powerful



Final drive of a Tracklaying Tractor (Allis Chalmers) to show how slipping clutches make steering possible.

starting gear must be provided. For the tough work these machines have to do, electric motor starting is unsuitable, as it involves an accumulator and the inevitable troubles that arise where that device is overloaded, as it certainly would be. So a small petrol engine is put in, easily hand-started, and able to spin up the main engine indefinitely at a good sound speed.

Details of the engine need not concern us here, they belong to another book, but it is of interest to mention that the biggest caterpillar can put 98 h.p. on to its drawbar—with a six cylinder engine—but if power is wanted from the belt pulley 113 h.p. is available. The smallest machine puts up 26 and 32 h.p. respectively, and in between are five others some, as we have said, dependent on petrol, paraffin, or tractor fuel.

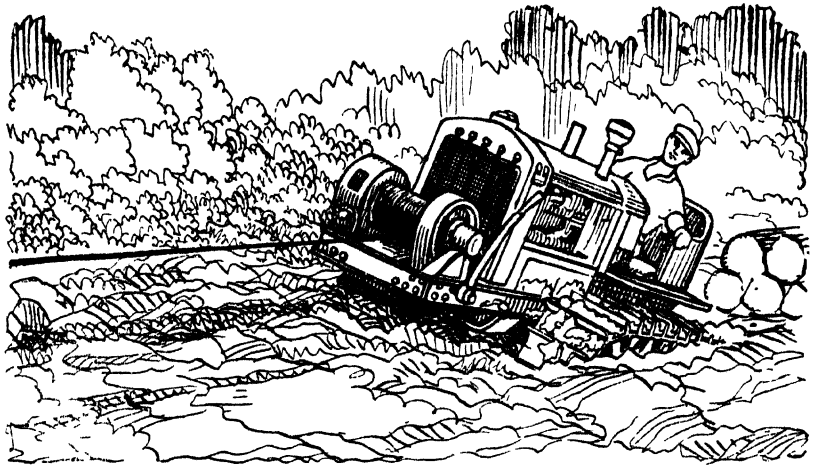
The matter of track bearing on the ground might be mentioned once more, the figures quoted for the largest machine are 3905 square inches and for the smallest, 1308 square inches.

Speed? Well, these machines are not built for that; the big fellow has six forward speeds which correspond to 1½ m.p.h. on first to 5 m.p.h. on sixth. There are two speeds in reverse. Drawbar pull is 26,111 lbs. on first gear, and 7,324 on sixth. Speeds are much the same for the smallest, though there are only five forward, and drawbar pull varies from 5,903 lbs. to 1,585 lbs.

Everything would seem to have been done to make these engines proof against normal troubles, they have come a long way since the writer first made contact with them in the war of 1914-1918, where they were used to haul heavy artillery, and at times somewhat indifferently! Forced lubrication everywhere, adequate filtering of fuel, and of air, these things are a matter of course today, but a revolution recorder to remind the mechanic that overhaul day is overdue, is a good idea. Every place where water and mud could seep in has been provided with a well-designed seal to keep oil in and water out.

Driving a caterpillar tractor is an exhilarating business, at least, for the first time. It is soon mastered by anyone with any mechanical abilities, but, apart from the matter of keeping the engine from stalling, experience with other forms of motor vehicle does not help a great deal. The power of the machine seems to be inexhaustible, it will climb up anything almost, and even with its tracks half buried in oozy mud, it still carries on.

This question of mud however must be reckoned with, for there is an obvious limit to what can be expected, and we have seen caterpillars bogged down, but by no means hopelessly so. Where there is any such risk, it is usual to fit a winch, with a power take-off from the engine, with an adequate length of



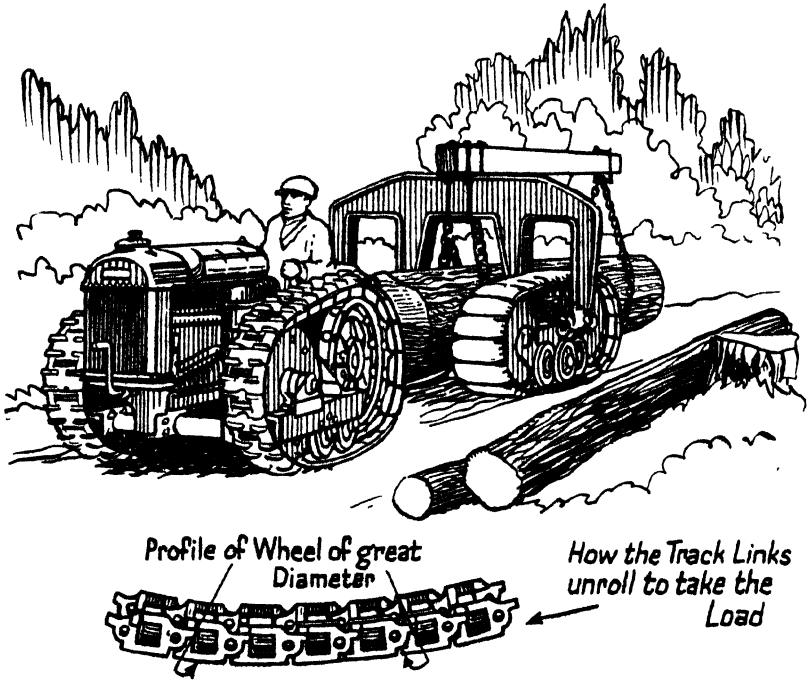
Even the tracklayer can fail to find the bottom sometimes. A winch and rope soon has it out of the worst situation.

steel-wire rope. The end of this rope can be made fast to a stout tree trunk, and the tractor will haul itself—and its load too—out of the slough in quick time.

For the operation of some of the machines that depend on this tractor's hauling and pushing power, another power take-off is often fitted at the rear. It consists simply of a clutch-operated drum with a supply of cable, on which a pull of anything up to two tons can be applied. This is available for use whether the tractor is going ahead or not.

There are, as we have said, other tractors that employ this track-laying idea—one has only to think of tanks, of course, to realise this—but apart from these, we have a British machine employing an ingenious principle. This is the Orolo idea, in which that part of the track that meets the ground forms itself into the profile of a wheel of very large diameter. This is secured by the formation of the links, which may be all steel or with rubber block inserts as shown in the sketch. Readers may have seen these tractors at work on the beaches where they

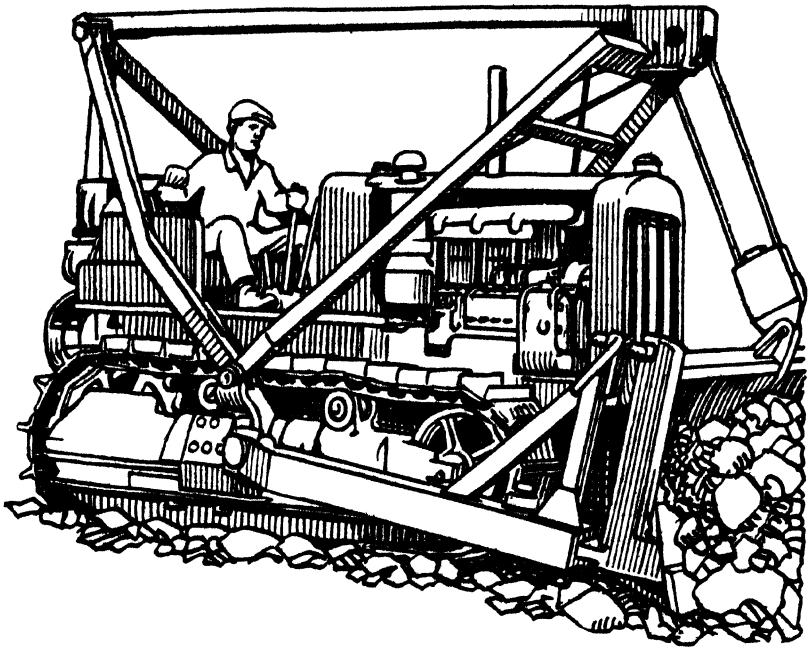
are employed to launch the R.N.L.I. Lifeboats. Another interesting feature of some of these tractors is the steering set-up. Instead of two clutches to drive the track sprockets, these are connected through a differential gear just as with a car. Separate brakes are fitted ; the application of one or the other has the effect of checking the motion of the track concerned,



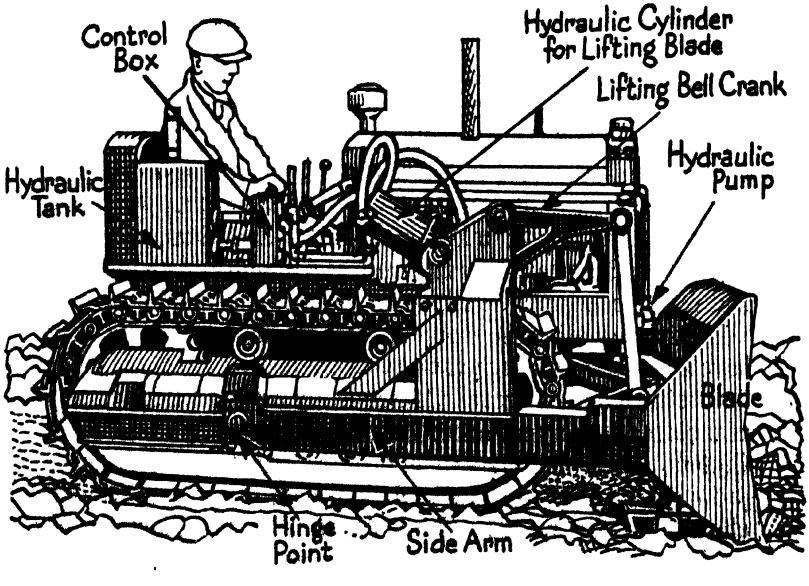
The Oroto principle provides a track that is equivalent to a wheel of nearly 40 feet in diameter, both for Tractor as well as trailer.

and the differential increases the motion of the other track in proportion. This method has advantages of a distinct character, because for one thing, power is not disconnected at any time from either track for steering. Thus the machine is under full control even with the heaviest load.

Having seen something of the tractor end of these site-clearing machines, we can pass on. In the old days, a big job of excavation or levelling had to be done by hand labour, and many of our roads and railways too perhaps have had to impose great labour on the machines that use them because of



A Bulldozer with cable control for the blade motions.



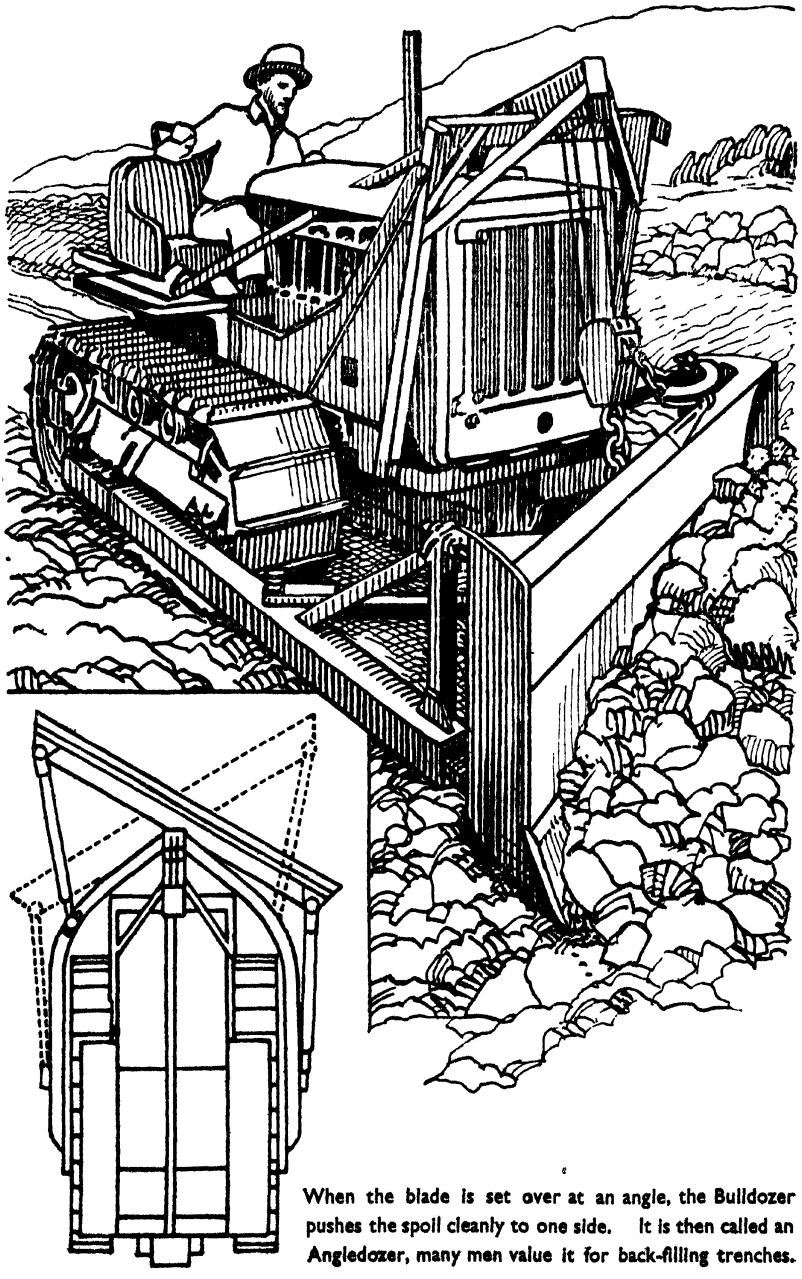
A small Bulldozer with hydraulic control for the blade motions.

the limitations that resulted. Today we should not consider such methods for one moment, we just fit some specially shaped cutter blades to the front of a tracklaying tractor and drive it full tilt at the obstacles, whatever they are. Not quite like that, but that is the idea.

The Bulldozer can be seen in the drawings, in three forms, all of them quite simple in construction. There is a shaped blade in front, carried on a massive frame attached to the main frame member of the tractor. The depth of this blade can be varied either by a hydraulic gear, or by winding tackle ; this of course alters the depth that it will dig out and is useful where trees have to be rooted up, or big boulders shifted. In some machines the angle of the blade can be altered to some extent so as to give an oblique action. The Angledozer has its blade set at a definite angle, and the cleared spoil is pushed well over to one side. This angle can be altered according to circumstances from one side to the other, the blade being pivoted in the centre. The usual limit is about 30° on either side, with an infinite range in between, and like the Bulldozer, the blade can be lifted or lowered. One of the things an Angledozer does extremely well is the backfilling of pipe or sewer trenches, completing a job that normally calls for a considerable amount of labour in very short time, consolidating the ground as it goes along.

The action of a properly designed blade is to roll the spoil forward, more or less as the blade of a wood plane rolls the shavings clear of the cut. By lifting the blade, trees can be pushed over, according to the nature of the soil and depth of root, certainly a ten inch trunk can be dealt with. Anything less than this can be taken in a stride, and those who can remember rough days clearing scrub and brambles with billhook and reaper can look with envy on the way it is done now.

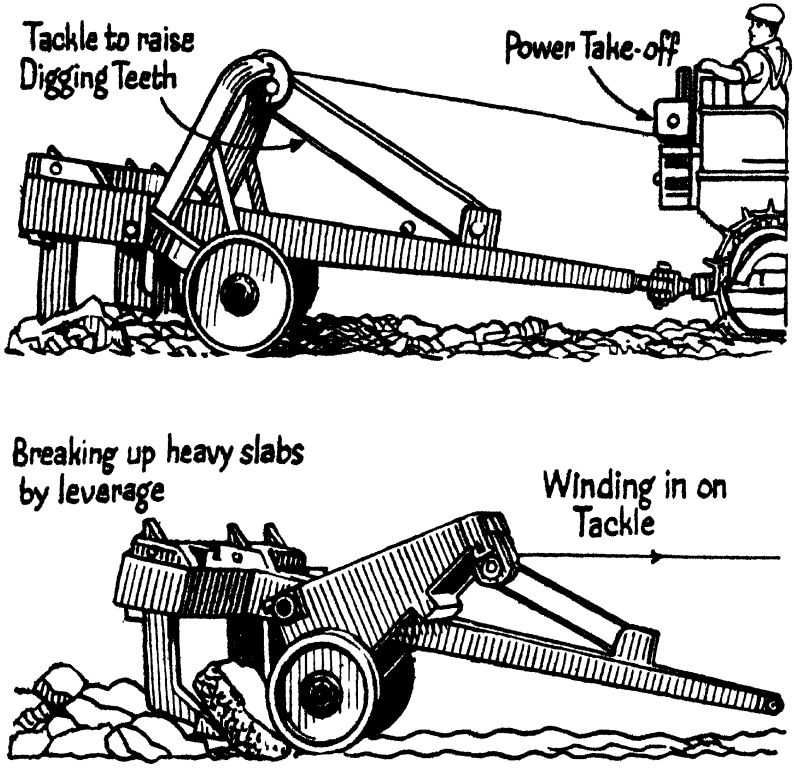
In America, where so many of these machines originate, they have still plenty of rough country where there is adequate scope for the most massive gear. Consequently we find a large variety of tools for attachment to the Tracklayer, Stump Splitters, Root Cutters, Brush Cutters—an impressive one this, for it has a prow like a ship, with saw teeth, and with this it goes straight ahead into the woods. Trees up to 8 inches diameter go straight down, and the spoil, if it can be called that, is laid in windrows on either side of the track. The Tree-dozer just



When the blade is set over at an angle, the Bulldozer pushes the spoil cleanly to one side. It is then called an Angledozer, many men value it for back-filling trenches.

pushes big trees down and digs out their roots, levelling the ground behind as it passes on.

The Rooter is another powerful tool that will follow along after the Bulldozer, though in some circumstances it may go first. This is also a simple affair, consisting of a group of digging teeth fixed to a massive carriage, these being set at a critical angle just right to get underneath all sorts of obstructions and dig them out. Sizeable boulders, heavy tree roots, all come out, and the soil is all loosened and torn up ready for the levellers. The digging teeth are adjustable as to their height by



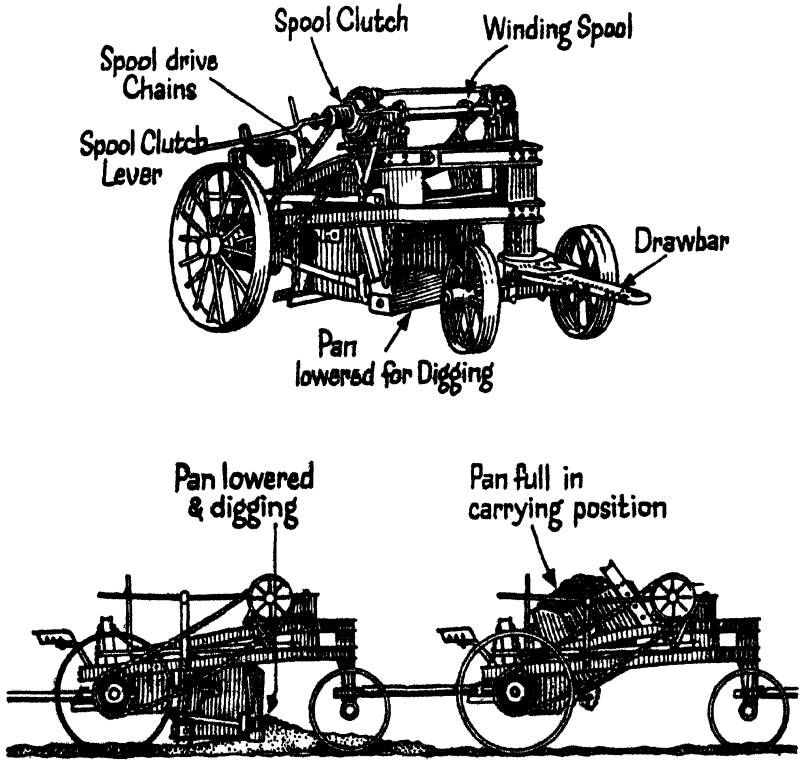
The Action of the Rooter is simple though forceful.

means of a cable and tackle from the tractor winch, and often when the outfit looks like coming to a stall, a touch on the winch lever will lift the teeth and bring the rock up with them too. Really that is all there is to it, these machines go about

the job in a headlong fashion, just challenging opposition and charging it down by virtue of the great tractive power of the tractor, and the skilful design and setting of the tool that does the work.

When the obstacles have been removed and the ground broken up to some extent, the Scraper can get to work. Here again the device is just exactly what its name suggests, being simply a large box with an open mouth, dragged along the surface until it is full. True it has a cutting edge that digs, and it has adjustments to vary the depth at which it will operate. Looked at from the side its action suggests that of the wood-plane, only it carries its shavings along as it goes.

There is a considerable variety in shapes and sizes of these scrapers, from a small affair taking a cubic yard, designed for



The American type of Scraper is used in trains of five or more, with two men to operate them.

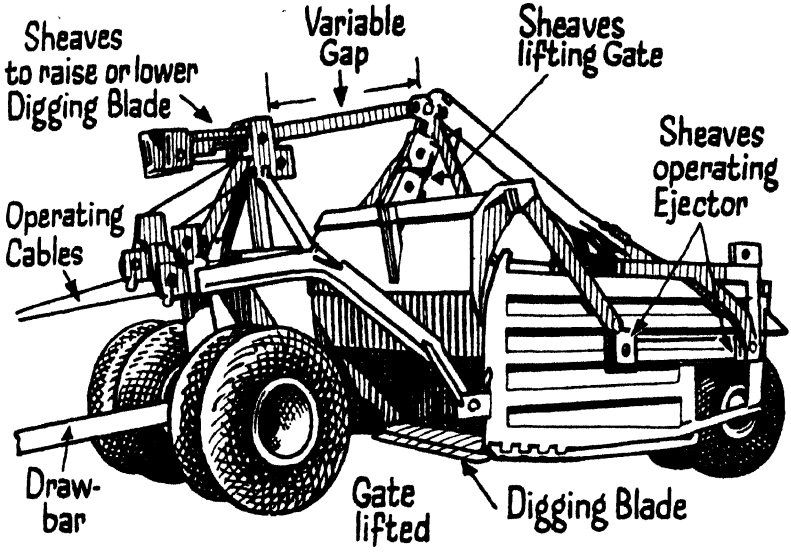
working as one unit in a train of five or six, to huge Carryalls made to accommodate 30 yards and to absorb the power of two tractors while it is loading.

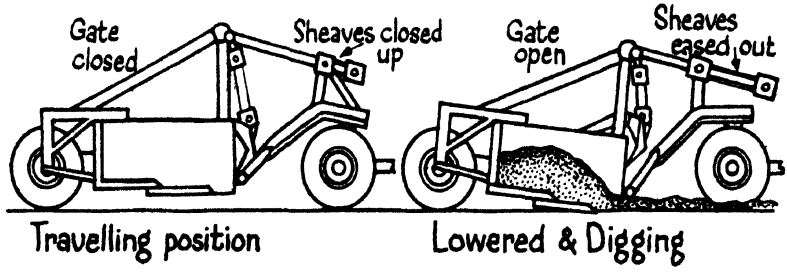
The method of employing the scraper is simple enough in principle, though the application of the principle may not always work out so simply. You just haul the scraper over the surface until it has picked up a full load, then it is lifted up to the position for carrying and trailed to the dumping place and emptied. Back to the loading point then for more, and so on until the necessary level has been attained. The surveyor decides where cut ends and fill begins, the spoil taken out being dumped to bring the fill up to the final level.

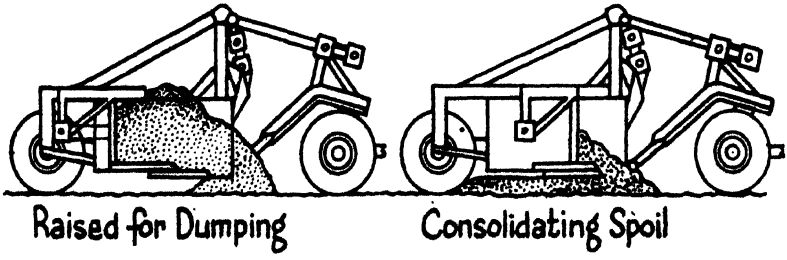
When scrapers are used in trains, say of four or five, they will not all pick up together, but there will be two men at the job to raise and lower the pans at the right moment. The first pan being filled, it is lifted, and the man at the second lowers that and remains with it till it is full. He then raises it, and as this is done the first man who had gone back to the third machine lowers the pan of that one and so it goes on. At the dump another man stands by to lower the pans for the dumping, which is done at the back, there being a latch door for the purpose. The bottom of the pan levels off the dumped earth so that there is a smooth surface left. The drawing shows a popular type of light scraper from the U.S.A., with the three positions. Like so many machines of an agricultural nature, it looks something of a contrivance, but it does the job. The work of lifting the pan is done by a chain-driven axle, engaged by toothed clutches on the rear wheels, and this winds up a chain to lift the pan to the carrying position. Dumping is a matter of jerking a chain to release a catch securing the pan door. As the pan is returned to the filling position again this automatically closes once more.

A train of five of these scrapers needs a tractor of 40 h.p. to haul, but it earns its keep with a good gang. They can fill a scraper in 15 to 20 seconds and be off to the dump in a minute and a half, provided the going is reasonably good.

The big Carryall type of scraper works in more or less the same way, but instead of hand operation, the power for its motions is provided by the tractor engine through wire cables and the power take-off at the rear of the tractor. A sketch of this is to be seen herewith. The scraper is mounted on massive







The heavy Carryall type of Scraper has seen much service here in the quick levelling of aerodromes. Its motions are controlled by cable and tackle operated from the hauling tractor.

pneumatic-tyred wheels, eight of them in the largest sizes. Altogether it is of the most massive construction, its work depends on sheer brute strength, all framing is of box section built up of formed plates welded everywhere.

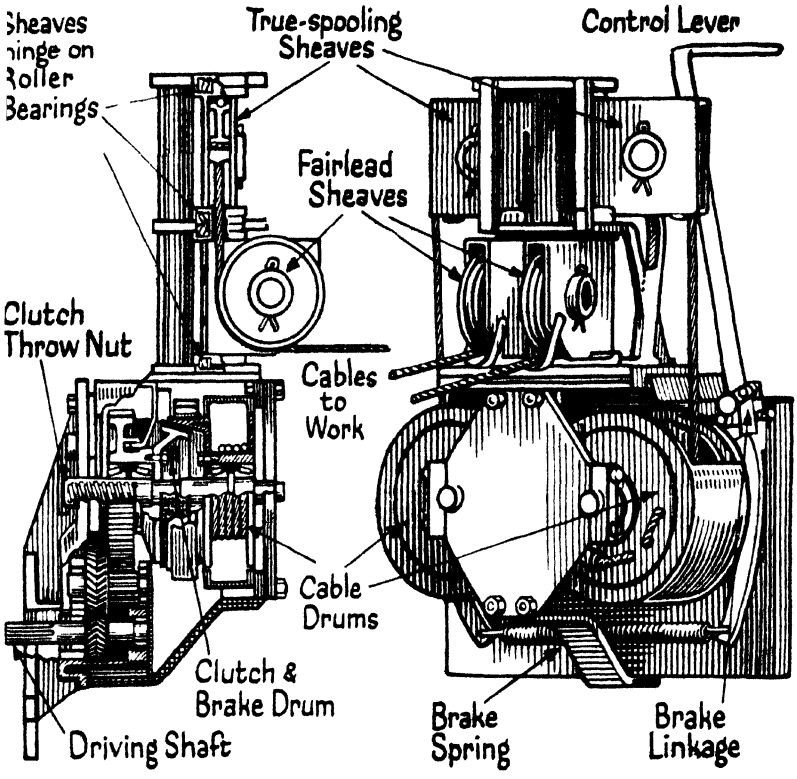
There are several motions for which power is required, these are illustrated in the drawings. First there is the adjustment for digging depth, this being effected by lengthening or shortening the distance between the two apexes by means of rope and sheaves. The diagram should explain this better than description.

The second operation is dumping. For this the back of the bowl is made to slide forward, thus clearing the spoil, and scraping the bottom and sides clean. All the contents are pushed out of the same opening by which it entered. Here again, rope and tackle serves. The back remains forward until digging recommences, and then the spoil driving in drives it back ; the clutch on the cable winding gear being released. The makers describe the movement of the spoil into the bowl as " boiling," and it is certainly impressive to watch.

Opening the massive hinged gate also calls for power, return being automatic, by gravity. When dumping, the bowl bottom smooths off the land and presses it down so that it is fairly well compacted at once. This is important where the spoil is employed to fill hollows, or to build up embankments for road or railway.

The Cable Control Unit employed for operating the various machines either mounted on the Caterpillar, or hauled by it, is illustrated, both in part section and perspective. It consists of one or two winches driven through reduction gears from the tractor engine, clutches of simple cone-form being provided to bring either winch into action as required. An ingenious arrangement of roller-bearing sheaves takes care of the running in or out of the cables. A single lever to each winch releases the automatic brake and puts in the clutch through a nut running on a quick-start thread.

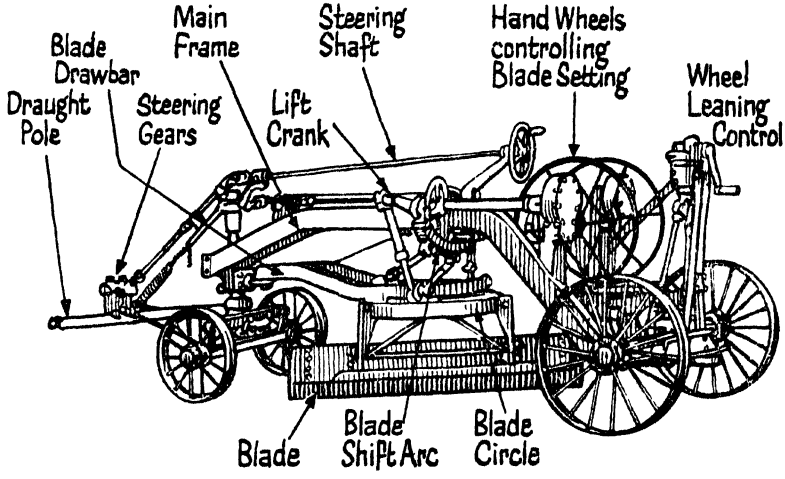
The number of different scrapers that could be included in this short notice is considerable, as also is the method by which they work, though the actual scraping process is much the same, that is the only similarity. However these two types reviewed must suffice as representative.

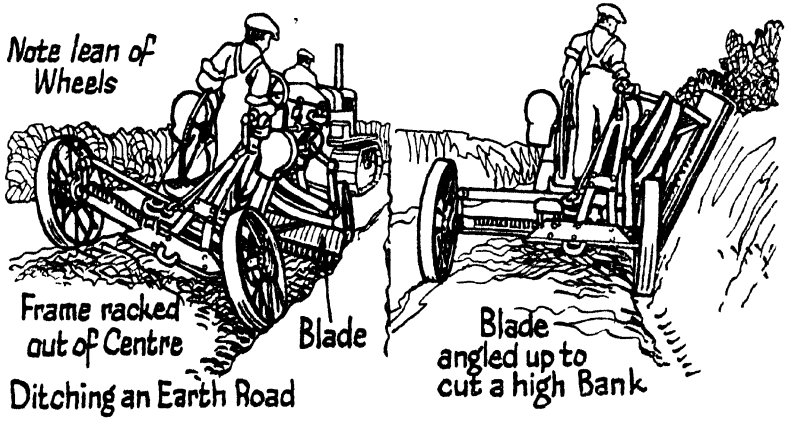


There are several of these Cable Control units to be seen, of which this Le Tourneau is representative. They provide for control of the machinery hauled through steel ropes.

Following on the scraper might well be the Grader, though this is usually employed only for the surfacing of roads. It has a wide blade of curved shape, the angle of which can be varied to a limited extent for giving a good profile to the road under construction. There may also be extensions of the blade ends upward or downward for forming the bank or ditch. A sketch of these machines is shown on the following page.

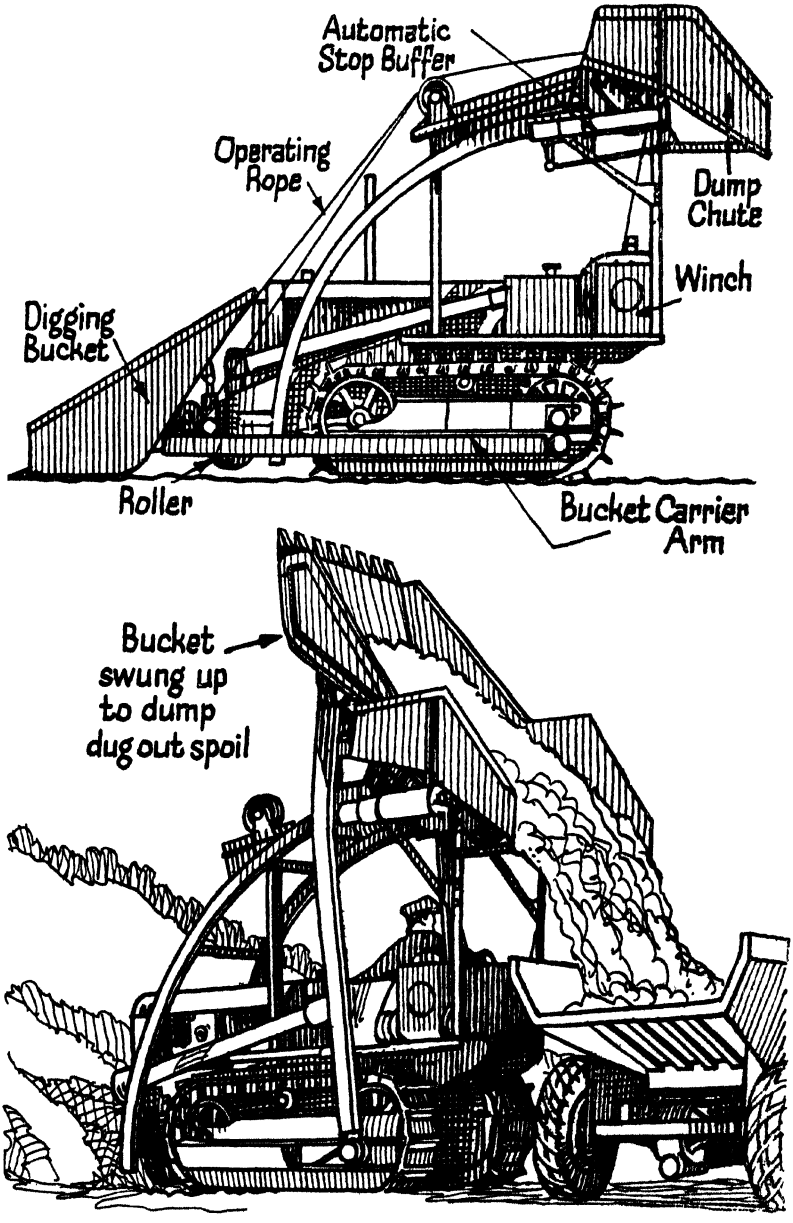
The next item is more properly reckoned as an excavator and should belong in the next chapter. As our first view of it in action was with a group of scrapers laying out an aerodrome in uneven country we include it here. This also is an American





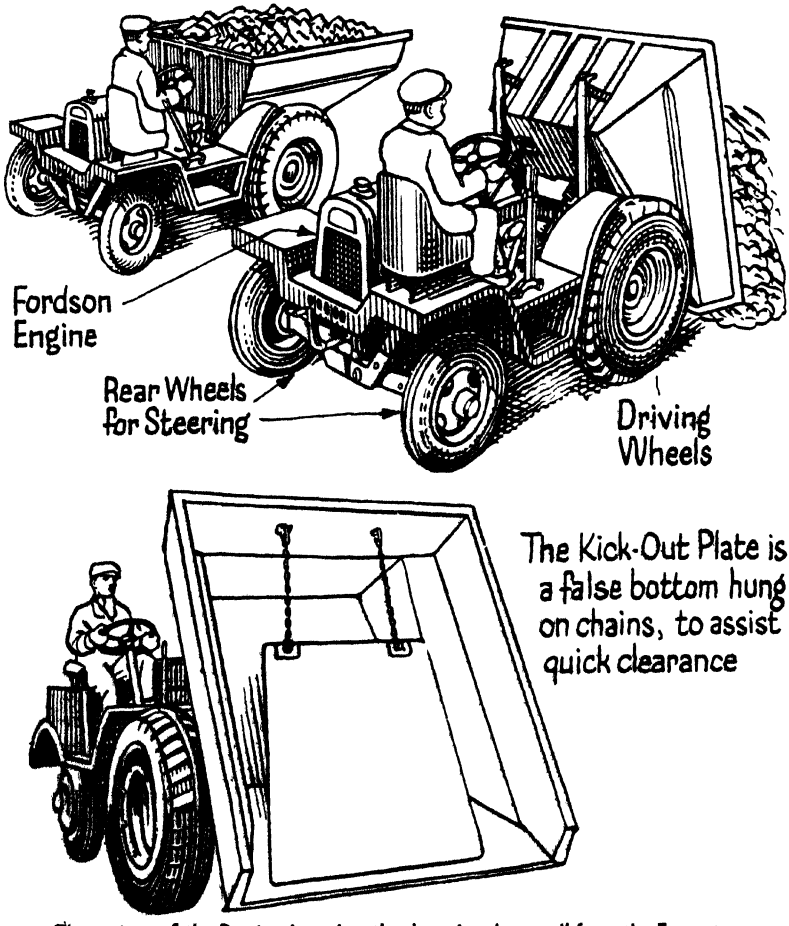
This type of Grader has a blade that can be set to any angle on either side to form road surfaces, ditches or banks. This is tractor-hauled, but some are self-propelling.

production, the Mobiloader, and it was cheerfully attacking a low cliff-like bank, digging out useful sand and gravel. The drawing shows it to be mounted on a standard Caterpillar tractor with rear power take-off.



There are various machines to do this digging-out, lifting and dumping work here shown. Their methods of operation vary, but the Mobiloader is representative.

A pair of quadrant arcs form a guide frame for the digging bucket, which swings on arms pivoted at the quadrant centre. Lowered into the digging position the tractor drives the bucket into the work until it is full, then the power winch quickly winds up, pulling the bucket up to the top of the quadrant where it dumps the load into a chute. A waiting lorry collects this and the bucket is returned for another dig. A full load of 1½ cubic yards can be dug out and dumped in about 20 seconds, and here again the process is an interesting one to watch ; one



The purpose of the Dumper is eminently clear, it takes spoil from the Excavator bucket and dumps it conveniently elsewhere.

can imagine the excitement it would occasion in city streets during lunch hours !

The work this machine can do is by no means limited to mere digging of earth, for anything that can be prised up and lifted comes naturally to it, the mention of city streets suggests the handling of old wood blocks from roadways.

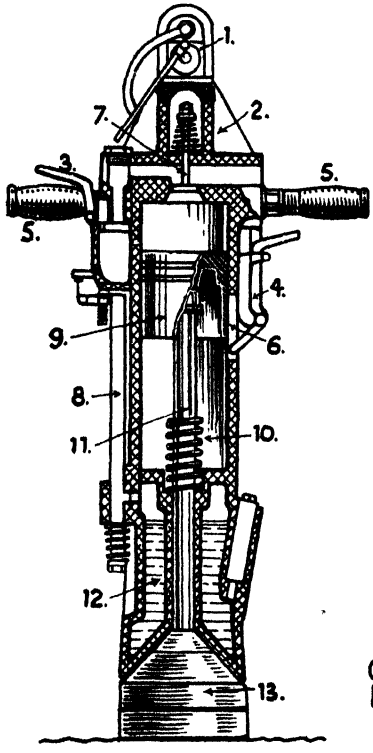
Shifting muck, as the contractor pleasantly calls spoil, is an important part of the work of site clearing. In consequence, handy tipping vehicles able to carry two or three yards have been produced. Representative of these is the one illustrated.

The body of this one accommodates 2½ cubic yards, which is collected from excavator buckets, or from the Mobiloader. Its heavy-tyred wheels which take the drive will travel over any sort of unmade ground if necessary, steering is effected by the smaller trailing wheels. The drawing of the vehicle in the dumping position shows the layout details well enough.

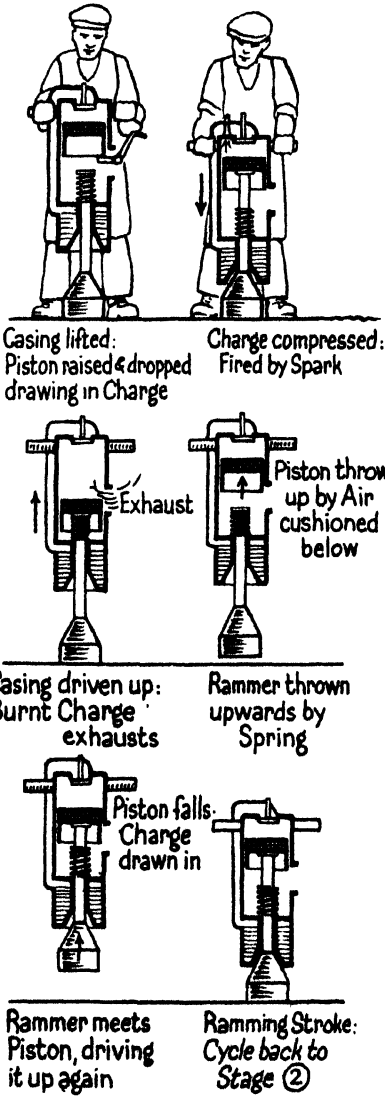
Normally, dumping is by gravity, when a catch is released, but if the load is unevenly piled, or the dumper is not level, some assistance may be needed. This can be provided by the reaction from an application of the brakes while the vehicle is on the move. Reversing brings the body back. Incidentally these dumpers are not made to comply fully with the Road Regulations, so they must not be used on the public roads. An improvement, in the form of a false bottom hung on chains, is also shown in the drawing. The action of this useful clearing device is easily understood; the plate throws forward as the body tips towards the vertical and everything is flung out.

We have dug up the ground and have levelled it by various means, and the next process might be one of compacting by heavy roller. However, this is rather outside our scope, but there is one very useful device that, incidentally, never fails to attract attention wherever it is employed. This is the Automatic Rammer, invaluable where trenches are to be filled in and the soil rammed to a good density. The following page of diagrams illustrate the machine and its action.

It is, in effect, an internal combustion engine in which the work of lifting is done by power of burning fuel. The initial processes in the cycle of operations are taken by the operator, who lifts the casing, then the piston is raised and dropped, thereby drawing in a charge of fuel and air. If the casing is now lowered, the charge will be compressed, and operation of a



1. Magneto
2. Cooling Fins
3. Magneto Trigger
4. Piston Lifter
5. Handles
6. Exhaust Port
7. Admission Valve
8. Suction Pipe
9. Piston
10. Spring
11. Piston Rod
12. Fuel Tank
13. Rammer Foot



An ingenious application of the petrol engine principle to take some of the back-ache out of ramming filled-in trenches. The sequence of actions is shown on the right.

trigger twitches the armature of a magneto to produce a spark at the plug points. This fires the charge, the casing is thrown up, the burnt charge escapes from the exhaust port and the sequence re-commences as shown. The whole thing weighs about 230 lbs.

Another machine of this sort is the so-called Frog Rammer that not only compacts the soil with a heavy thump, but also works its way forward with every jump just sufficiently to completely cover the ground. It weighs half a ton. The travelling motion is effected by the forward inclination of the machine, the centre line being a few degrees out of the vertical. Due to this, the weight is thrown forward at each jump, a matter of about eight inches each time.

It frequently occurs that work has to be done in ground that turns out to be waterlogged below the surface, and which will not respond to ordinary methods of excavation. Within the last few years various schemes have been adopted for dealing with such circumstances. Once upon a time an attempt was made to encircle the bad ground with steel sheet piling, the interlocking edges of which will keep out anything but a tiny trickle of water, but this is an expensive method.

By the new way—known as de-watering—the ground is literally robbed of all its held water, and becoming firm instead of wet and soggy, remains capable of standing up round the sides of quite a deep pit without the need for more than a few timbers for support.

The basis of this idea is the well-point, for fuller details see page 212, gauze-covered tubes sunk 3ft. apart, 18ft. into the ground in a circle surrounding the site. Powerful pumps then draw the water from the ground by way of these points. Getting them in can often be a tough job. Most wet soils will be loose, and easily dealt with by jetting pump, but when this is not the case, the engineer and his gang may well be up against it.

One violent method is to use a 20ft. steel tube that will freely accommodate the well-point, slotted at the top to allow for the swing arm to be coupled up as required. This tube will be driven in by piling hammer as far as possible, suppose we say about six feet. The well-point is put in and the jet turned on, and a shower of stones and muck shoots high into the air from the top of the tube. Now the piling hammer drives again and

another foot or two will be gained, to be followed by the jetting pump, and so on until the well-point has perhaps reached the required depth. If it does so, the steel tube is then withdrawn, to leave the well-point well embedded.

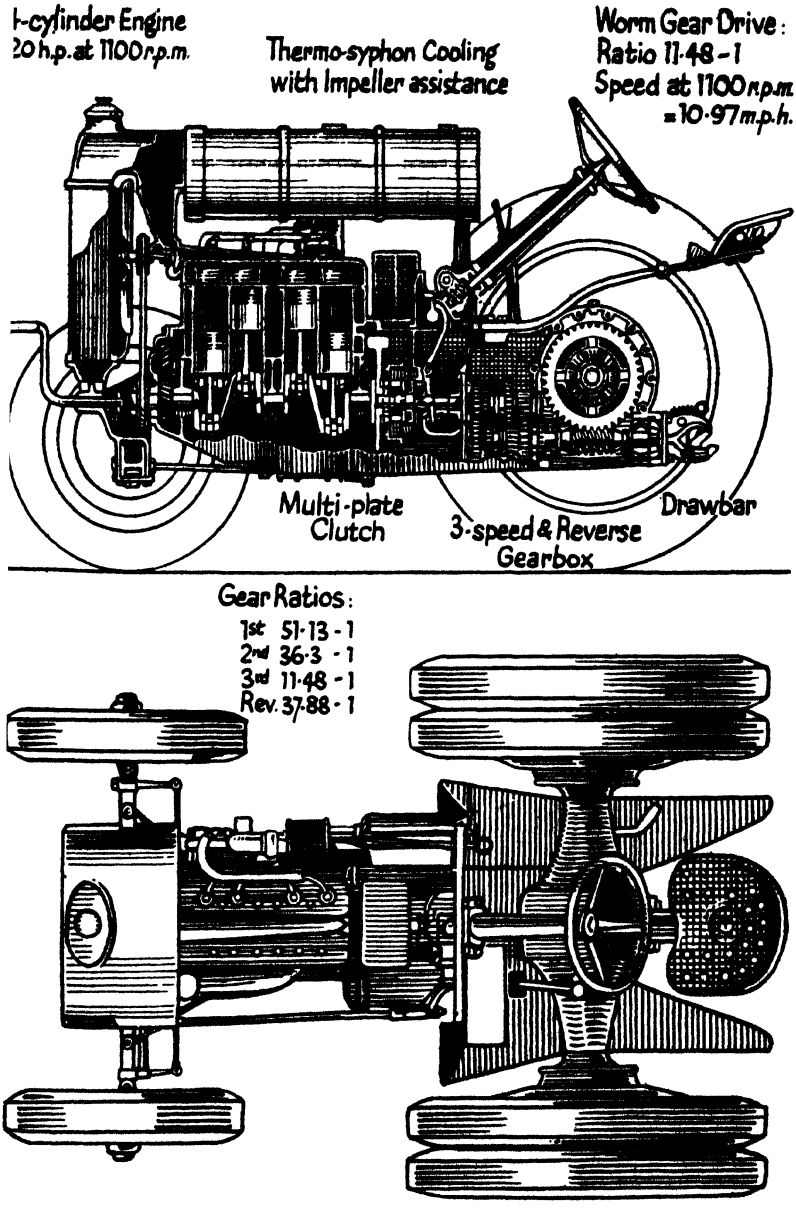
If the ground is really stony, it may not respond to the jetting pump alone, and in this case it may be necessary to use a heavier hammer and to assist the water jet with blasts of compressed air. Each blast sends a miniature volcano out of the top of the tube, stones, mud and what not, much to the inconvenience—to put it very mildly—of the men who are holding it. They will achieve success in the end, but it is a dreadful struggle, and it may be an equally horrible job to get the enclosing tube out. But it will be done, it must be, because the big job cannot begin until the site is dry.

There are other methods of dealing with this difficulty, but they are rather more elaborate, and generally speaking, not so quickly available as the well-point method. One very often employed where deep shafts, such as new mine shafts, have to be dug through wet strata, is to freeze the soil into solid ice rock. This is done by sinking tubes filled with brine, in much the same way as with the well-points, encircling the projected shaft, and in each of these a small gauge tube is inserted, connected to a powerful refrigerating plant. It will take some time to freeze the soil, and even when this is achieved, the refrigerator must continue to work until the shaft has been dug through to dry levels and lined with brick and concrete or iron tubbing.

Another method is to inject silicate of soda, followed by common salt, in solution of course. This solidifies the ground, and the method has been employed to stiffen such soils as quicksands, making possible the cutting of tunnels through such obstacles.

Again, there is the cementation principle, in which cement is used. The grouting of tunnel linings to seal them against seeping water is an old idea and a valuable method employed to a considerable extent. Some further mention of this is to be found elsewhere in these pages.

We commenced this chapter with a reference to the tractor power that has made so many of the heavy earth-moving devices possible. Let us end it with an acknowledgment of the valuable services rendered by another tractor, one that has



The Fordson Tractor is as well-known amonst field engineers as it is with agriculturists, providing for a variety of haulage requirements.

found much favour with contractors' men, the Fordson. There is not much that need be said about it, a page of sectioned drawings illustrate its general arrangement. It is available in several forms, with wheels carrying pneumatic tyres as shown, or with the more usual spiked wheels as needed for agricultural work. Features that interest the contractor are recorded on the drawing, gear ratios and the like. It is a commonsense sort of design with the minimum of frills, if any, but there are no omissions, that one can see, of anything that would be of value in promoting the economical haulage of heavy stuff on wheels or otherwise. In addition there is the belt-pulley for power take-off usually found on agricultural tractors and for which the contractor can often find a task.

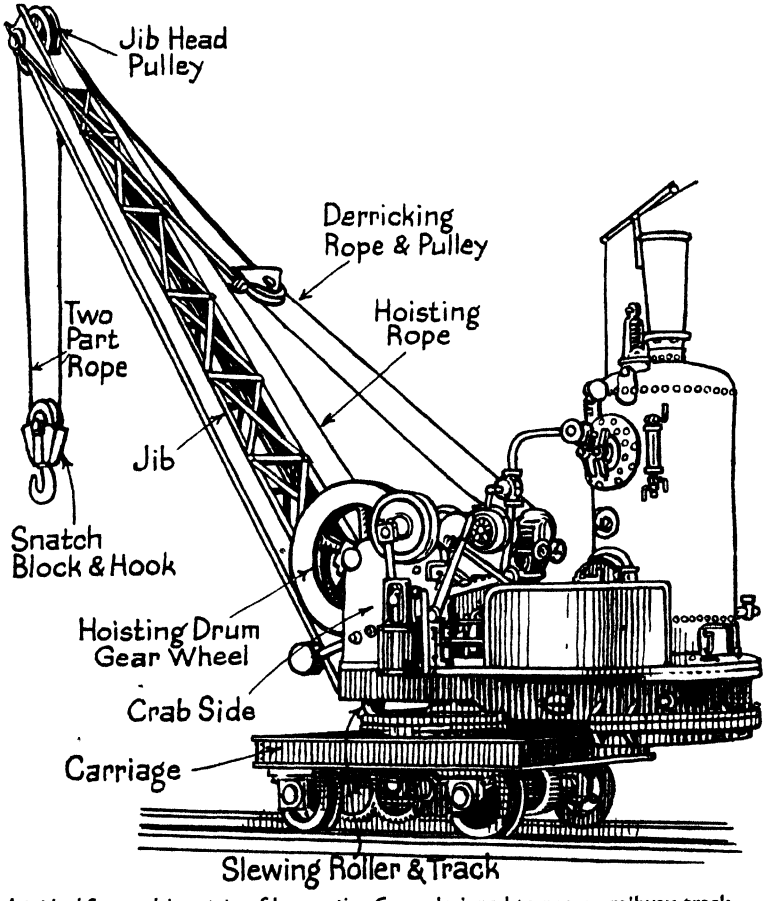
Chapter 4

CRANES.

THERE are not many mechanical devices that can be considered more useful than cranes. This simple mechanical contrivance, dependent upon the principles of the wheel and axle and the pulley, as well as the increased leverage of the toothed reduction gear, is found in a very large variety of forms. Out of these there are not more than two or three that can be considered as of direct interest to the contractor; the fixed type and the locomotive type. Let us first look at a very simple type, so that we can get a clear idea of the various movements that are necessary if the crane is to be fully useful.

First of all, obviously, a crane must be able to lift and lower its load within a reasonable range. This motion is usually referred to as Hoisting, and is carried out by means of a wire rope or chain wound on a drum, gear driven from the source of power. To give as much clear lift as possible above the level of the ground, the hoisting rope is carried over a pulley, or sheave, at the top end of a jib. This jib is made with a good length, and is hinged to the crane platform. It is supported by tie rods and a pulley, over which a rope passes, secured at one end of the frame—or crab, as it may be called— the other end being wound upon a drum that can be driven by the motive power if necessary. In this way the jib can be raised or lowered, the load being traversed along the centre line of the jib when this is done. This motion is called Derricking or Luffing, but unless the hoisting drum is used at the same time, the load does not travel truly horizontally which may sometimes be a disadvantage. Dock and wharf cranes are often provided with

an automatic arrangement to counteract this, called a Level Luffing Gear, but such a refinement is not likely to be met with on contractors' cranes.



A typical Steam-driven type of Locomotive Crane designed to run on railway track.

The Crab will certainly be free to swivel on its platform, whether of the fixed or travelling variety, and of course this swivelling motion will be carried out by means of gearing that can be coupled up to the engine. A locomotive crane will be able to turn full circle, but a fixed crane will be limited in this respect. When erecting a fixed crane the engineer will have to consider carefully the field over which he wants it to be available

before placing the supporting towers. There is a type of fixed crane, that we shall see in a moment, that does give an all-round radius of action.

Finally, we have the Travelling motion, in which the crane travels bodily, load and all, along a fixed track, usually composed of railway lines. This motion is not available to the fixed crane.

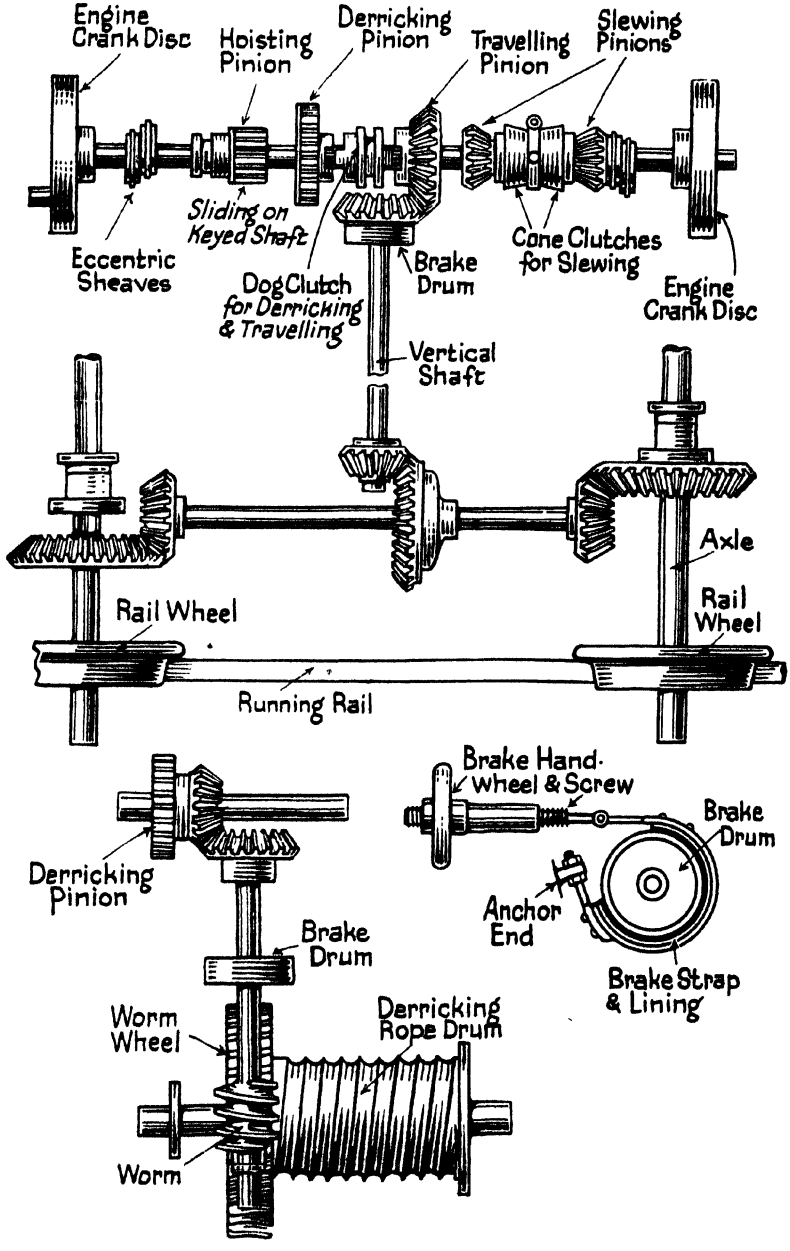
These four motions are all dependent upon a single engine, which may be steam, or as is now preferred in many cases, oil driven. A steam engine requires continuous attention ; its boiler must be washed out from time to time, the fire grate has to be cleared of clinker and ashes, it has to be fired at intervals, and a continuous supply of good boiler water provided. On the other hand, the oil engine works continuously, starts up easily and is ready for full duty in no more than a minute or two.

Each motion has a powerful brake to hold it firmly in any given position, and a positive clutch to couple it to the engine shaft. It must also be possible to couple more than one motion at the same time to the shaft, as when derricking to keep the load level.

The holding brakes are usually of the friction band type, in which a steel drum is encircled by a steel band lined with some form of woven asbestos that will not be damaged by heat. The band will be clamped tightly upon the drum by means of a lever, pedal or hand operated, or else by a hand wheel and screw.

Various forms of clutching gear may be employed for engaging the driving shaft with the motion shafts. The small gear pinions may slide slong on a keyed shaft, sliding into engagement with the large gear wheels ; others may be connected by cone, or dog clutches. Here is a sketch of the engine shaft of a locomotive crane to show something of these details. With steam engines, which are easily reversible, no special arrangement has to be made for running in both directions, but the oil engine is not reversible, and so a reversing gear has to be put in for this purpose.

The slewing motion must be possible in either direction with the engine running and coupled to the hoisting drum, so two pinions are provided for this purpose. In this way, the load can be slewed either way while hoisting is going on, often a necessary combination.



Laid out for inspection are the principal motions of a Locomotive type Crane. The hoisting drum has been omitted ; but its pinion is shown.

Opposite is a drawing to show the engine shaft and two of the sets of gears for the motions. The hoisting pinion slides along the shaft, but has to turn with it because there is a key on the shaft, and the same remark applies to the dog-clutch sliding between the derricking and travelling pinions. The hoisting pinion slides along to engage with the large gear wheel on the hoisting drum, and it can remain in engagement with it whatever other motion is clutched in. In the case of the derricking and travelling pinions, however, it is only possible to engage one of these at a time ; they are both free on the shaft, but either can be locked to it to engage their drives by sliding the dog along, this being keyed to the shaft.

Finally we have the slewing pinions, both of which are free on the shaft, and either can be locked to it by cone clutches. They both engage with the same bevel wheel, but on opposite sides of it, so that the bevel will be turned in one direction or the other just according to which one is brought into engagement.

Down the centre will be seen the train of gears that takes care of the travelling motion. The shaft marked " vertical " is set upright and passes down through the floor of the crab, there to drive another shaft set at right angles to it. On the ends of this shaft are two bevel pinions, driving crown wheels keyed to the rail-wheel axles. Half of each of these only is shown.

The derricking gear is illustrated below. This consists of a drum, on which the rope is wound, driven by a worm gear. The worm is single thread and so is of the irreversible type, no matter what pull comes on the rope, the drum cannot turn at all.

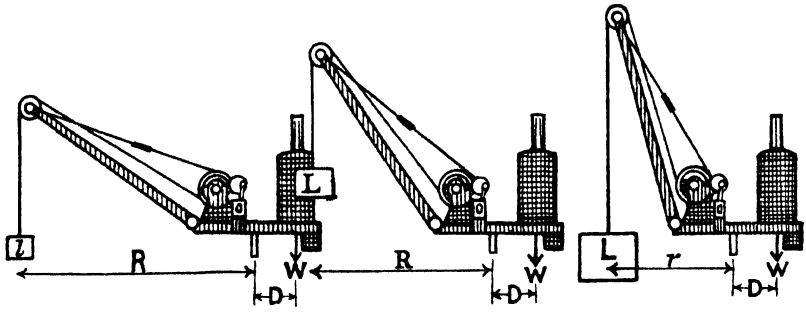
Another sketch, at the side, shows the principle of the band brake generally used in machinery of this sort. A hand wheel and screw is used for putting on the pressure in this case, but with the hoisting drum, where quick application as well as taking off of the brake is very necessary, a pedal giving powerful leverage is employed.

The slewing arrangements are simple. A heavy pivot is bolted to the carriage, and the crab turns on this, roller wheels being provided to make rotation free. A toothed ring also bolted to the carriage is engaged by a plain pinion, driven by a shaft and bevel wheel from either of the two slewing pinions.

These motions have been dealt with in some detail because they are common to all cranes, though the method of coupling

to the power unit may vary in individual cases, the principle is the same.

It ought to be clear that the load that can be safely handled by such a crane—or any crane for that matter—depends upon how far out from the centre of the crab the lifting hook may be. In other words, the angle at which the jib is carried really governs the safe load. If the jib is drawn right up as far as it will go, then the radius of action is at a minimum, but the load that can be lifted is a maximum. When the jib is fully lowered,



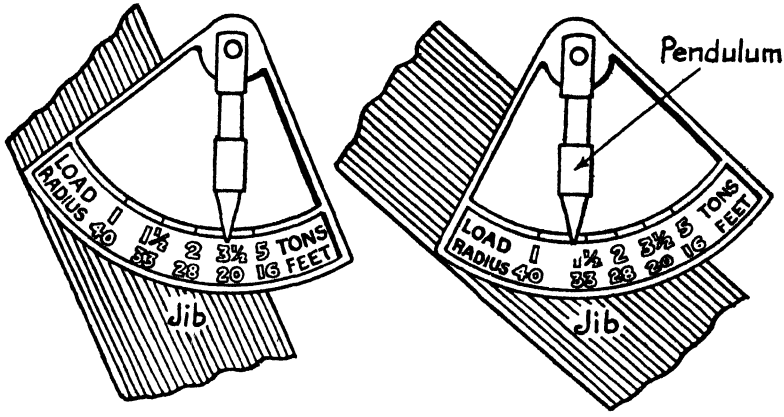
W..... D must always be well in excess of L R to maintain stability in any crane.

the radius is a maximum, but the safe load is much reduced. Any attempt to exceed what is determined already as a safe load will result in overturning the crane.

A diagram to illustrate this point may be studied here. Three angles of jib are shown, giving radii of action **R**, R or r. The counterweight and its radius from the pivot is the same in each case—W and D. For exact balance, W × D is to be equal to the Safe Load × the Radius ; so, **R** being maximum, the Safe Load (l) is a minimum. Contrariwise, radius being minimum (r), L is maximum. For stability W × D must always be well in excess of L × R.

To ensure that this safe load is not exceeded, most crane builders provide a clear indicator to show what the maximum load must be for any angle of the jib. This is a simple device with a pendulum pointer moving across a quadrant ; we illustrate one of these, as fitted to a locomotive crane of the type already described. As the jib is raised or lowered, the pendulum pointer maintains the perpendicular position, marking on the scale just what the radius is and the consequent safe load.

Unless the crane driver knows the exact weight of the load, he cannot be sure that he is keeping inside the safety limit, but there is a crane load indicator that tells him at once whether the load will be safe just as soon as the hoisting rope begins to



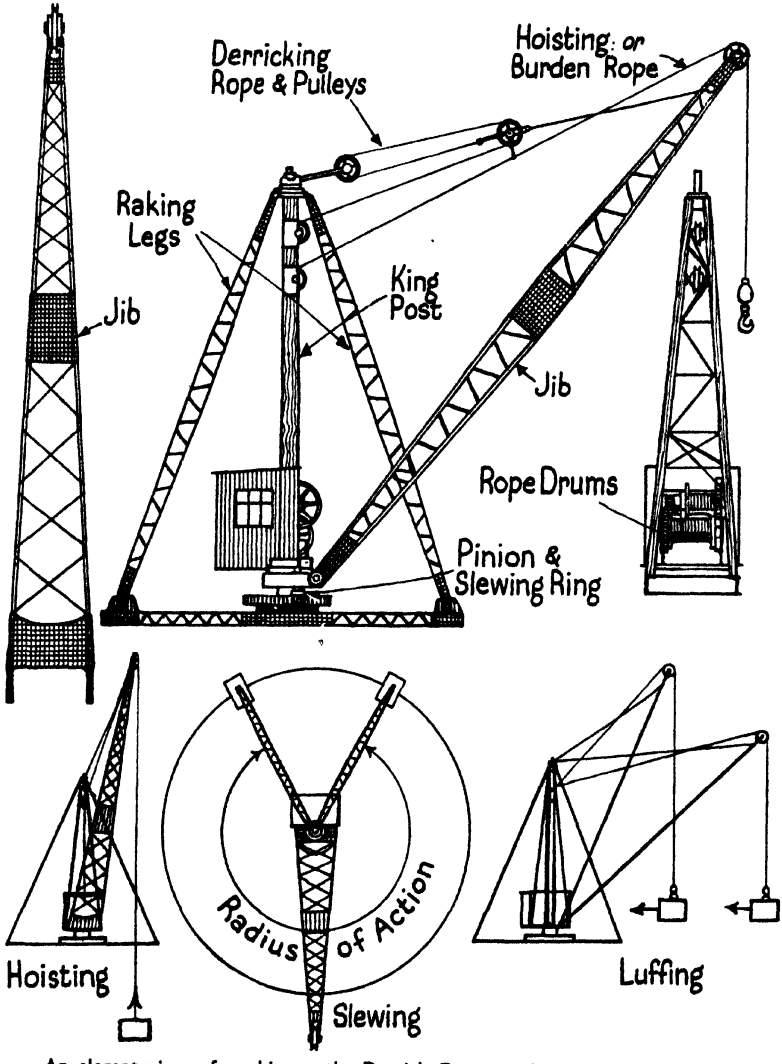
The simplest form of Safe Load Indicator. As the angle of the jib alters, the pendulum pointer makes a fresh indication.

tighten up. However, with the contractor, who uses cranes of this sort to handle skips full of spoil, concrete, or other material of which the average weight is known nearly enough, such a refinement is a luxury almost unknown. With the derrick crane, things are different, and we find that much more elaborate arrangements are provided.

Mention of the Derrick Crane brings us to this most elegant apparatus, of which we give an illustration here. We have mentioned this machine previously, but there are several details that must be added to those already described.

The cab containing the machinery is built on to the central mast, or king-post, pivoted at the base on to a fixed gear ring. At the top it is also pivoted into, and supported by the gland irons that make the ends of the long raker legs. These take the load, transferring it to the two corners of the platform, on to each of two of the gantry legs. The arrangement can be seen in the drawing clearly enough.

To get some idea of the size of these derrick cranes is not too easy, but a fair sized one will have a mast 40 feet high, the height of a four-storey house. The jib will be 100 feet long.



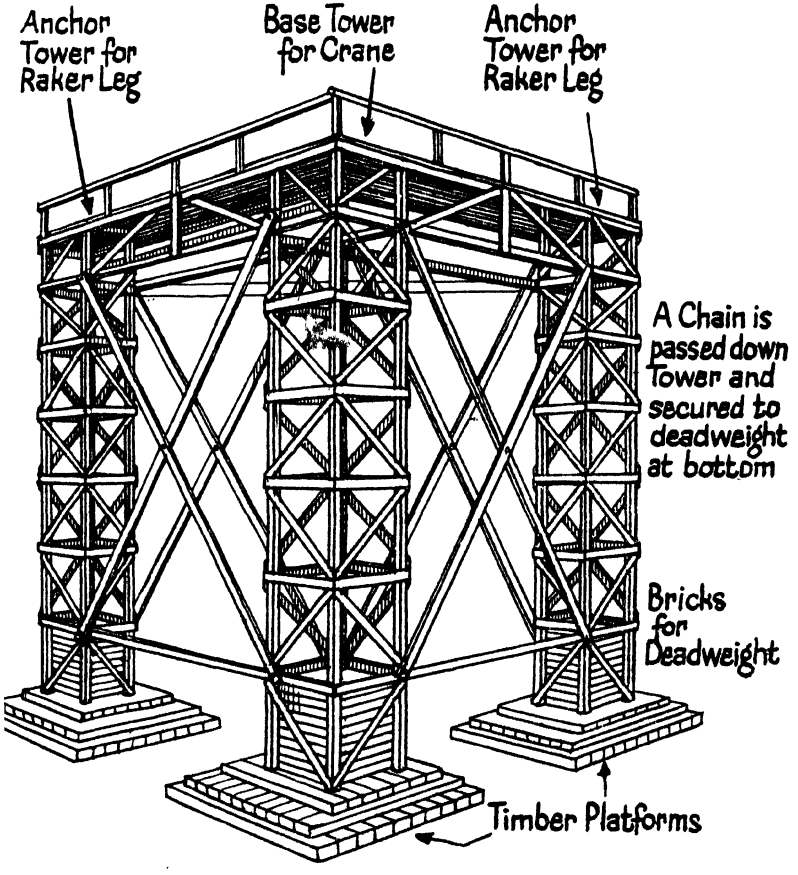
An elegant piece of machinery, the Derrick Crane, with some of its motions.

To do the work there will be three motors, 40 h.p. for the hoisting, 32 h.p. for luffing, or derricking, and 8 h.p. for slewing.

The jib is a work of art indeed. It must be as light as possible to avoid lifting unnecessary weight, strong enough to

withstand the proper load of 5 tons, but sometimes as much as 10 tons if the driver gets hold of some such load as a steel pile stuck hard in the ground, or perhaps jerks a load of timber so that it suddenly drops an inch or two.

Occasionally a driver will start his jib coming up, and then

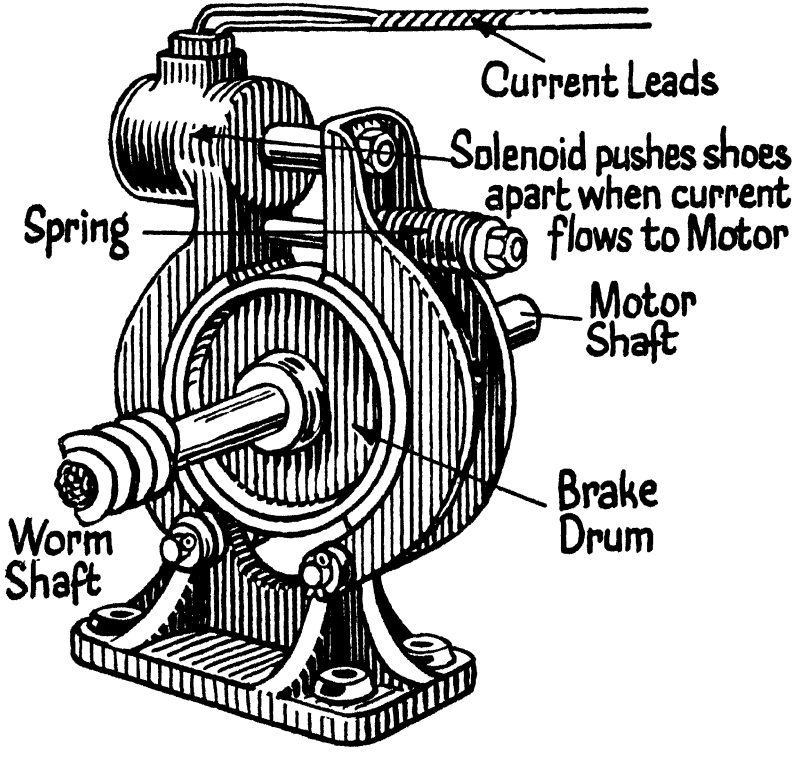


A typical Wooden Gantry for a Derrick Crane, not so much seen today, but formerly in general use.

look out of the cab to pass the time of day with somebody. The crane then performs the feat known as "pulling the jib through the cab." This is most distinctly disadvantageous to the jib, especially as the ropes, being five times as strong as they need be for real safety, refuse to give. The usual result is a

crumpled mass of angle iron and the loss of a few hundred pounds, but if the plant engineer's luck holds, he can retrieve something. He cuts away the worst bits; then straightens others, and with rivets, bolts and angle iron soon has the job looking as good as new again. Be sure he will always remember that jib, even if it is sold, and he does not see it again for some years.

Formerly when all the motions of a derrick were performed by a single motor, the driver always had a fear that his jib might fall when he was changing from one gear to another. Now it is separately handled by a motor with irreversible worm-gear drive, with an adequate brake. This acts upon a drum on the motor shaft, it has two part-circular pads lined with asbestos friction material arranged on a pivot that allows the two halves



An automatic Electric Brake for hoisting machinery. The hoisting motor current passes through the solenoid coils and the brake is held off.

to be gripped tightly against the drum. On the top side the pads are squeezed by a strong coiled spring against the drum, whilst at the side is an electric solenoid which, when energised by an electric current opposes the spring and pulls the brake off.

Here then is the safety device. As long as no current is passing into the derricking motor, the brake is on ; as soon as the motor controller is moved one notch, current energises the solenoid and releases the brake. It will be seen that the motor has now got control of the jib, and immediately current is switched off, the brake takes charge again, though the irreversible worm gear prevents the derricking rope from running out.

The derricking rope is arranged as a two-to-one pulley effect, so reducing the actual pull of the rope by one half. Hoisting is direct, but the rope has to pass vertically up the mast to a pulley before it goes out across to the head of the jib.

Slewing can be carried out over two-thirds of a circle, so when erection is contemplated, the placing of the legs has to be carefully arranged in relation to the area over which work will have to be done.

To warn the driver against trying to pick up too heavy a load, regulations have been passed by the Board of Trade, insisting on the fitting of safe load indicators to all these cranes. Of these there are several types. One depends upon the bending of a strip of steel, another on a pendulum (already shown), yet another on the movement of a small weight. This one requires the derrick guy rope to be brought around a wheel protruding from the front of a heavy steel plate box. This wheel is carried by a lever turning on a pin passing right through the box. The greater the pull on the wheel, the more the lever tends to turn on its pivot. At the other end of this lever, which is cranked, is a grooved wheel, round which is passed a cord connected to a series of magnifying levers. A pull on the short end of one of these can be balanced by a much lighter pull at the long end, so by compounding the effect of these, a pull of several tons can be balanced by one of a few pounds only.

This final pull has the task of moving a heavily bobbed pendulum about its pivot, and by means of a suitable brush, connected to a source of current, moving across a curved contact plate, will light up either a green or a red lamp in full view

of the driver in his cab. A loud bell also rings when the red light glows.

Each motor has its own separate controller, much the same sort of thing as is seen in the driver's compartment of a tram-car. Inside this controller is an arrangement of contacts on a drum rotated by the driver's handle, with contactor brushes to pick up current from the drum contacts at the correct intervals. The actual speed control is carried out by resistances of varying lengths, arranged in an openwork metal box allowing air to circulate freely for cooling the coils. Behind the driver is another control box, with three electric lamps and another small switch. This latter switch is a sort of master switch for everything, for it supplies current to a solenoid lock to the main " breaker " switch, an automatic cut-out that flies open if the driver moves any of his controller handles too quickly. Doing this would in all probability burn out the motor windings with the rush of current that ensues with the armature standing or only moving slowly.

If the driver wishes to switch off for the night, or to examine one of the motors without risking " taking a packet " as he would call it, he need only knock off the small switch, the big one looks after everything else. So long as all the circuits are alive, the lamps—one to each motor—are alight, if one of them goes out, the driver then gets an uneasy feeling that there may be trouble about, and for him particularly.

The erection of a large derrick is not a difficult affair, if the plant engineer has a good gang, and has looked the crane over before it was dismantled. To do the job with unskilled men when the outfit is delivered in the form of a mass of gears, shafts, nuts, bolts and the like, is a very different story.

Sometimes a small hand crane can be erected, but more often than not the only help that will be available is a large pole, a chain tackle, and some long hemp ropes. The pole, which will have to be about 40 feet long, and about the dimensions of a good telegraph pole, is first stood on end close to the future position of the crane mast, with guy ropes leading from the top, fastened to iron stakes driven into the ground to keep it upright. The chain tackle—a Weston differential block—is secured to the top of the pole ; a chain sling can then be secured to the crane mast at such a point that the mast when pulled up will hang as nearly plumb as possible. Having

lowered it so that the bottom sits on the vertical pin of the slewing race, guy ropes are fixed to hold it vertical while the first of the raker legs is raised by the tackle. Here again, careful slinging is more than half the battle, for the gland iron at the top of the raker leg has to be steered over the pin at the top of the mast. As this pin is, or should be, a nice running fit in the gland iron, the slightest error in slinging results in a jam, which can only be cleared by one of the gang climbing up the raker and putting in some hard work with a crowbar, whilst the rest of the gang heaves on the other end.

At last it drops down nicely, and the other raker is similarly dealt with ; the worst of the struggle is really over. After this it is only a matter of patience to assemble the hoisting drum with its gears, motors, brake and the rest. This done, the cab is erected, and the driver gets to work cleaning and oiling his charge.

The rest of the gang will now join up the two sections of the jib, for a hundred footer is much too long to be carted about in one piece, whilst it is so frail that great care must be taken to get it built in true line with itself. Also, it must be propped up with the sheave end higher than the foot, for if an attempt is made to pull the jib up with the sheave lower than the foot pin, it will buckle.

There are times when a derrick crane has to be set in a certain position, to do some of the work for which it is intended, but swung around to a new position shortly afterwards. The engineer can either take the crane down and rebuild it in the new position or else swing it around bodily ; this latter method being, of course, quicker and cheaper. If erecting a crane is difficult, then swinging it is a real twister, for the whole thing, including the jib, has to be worked round on improvised rollers. Any obstructions in the way of the jib as it sweeps round have to be bridged, and the jib end jacked up high enough for it to pass them.

Jacks, crowbars, chain tackle, wedges, rollers, slings, spanish windlasses, in fact every device known to the plant man comes into use during the 25 to 30 hours continuous work necessary to complete the task. Hard job as it is, completed, the engineer and his gang can take pride in it.

Before the crane can be put to work, it has to pass very severe

tests, under the supervision of an insurance company's inspector.

Reference to the drawing on page 72 shows the tendency of the crane to tip about the mast base when the load comes on the hook, the top of the mast being firmly held by the raker legs. To prevent this overturning, the raker legs are bolted down either to blocks of concrete set in the ground, or to wheeled bogies loaded with lumps of pig iron, tanks of water or some other convenient weight.

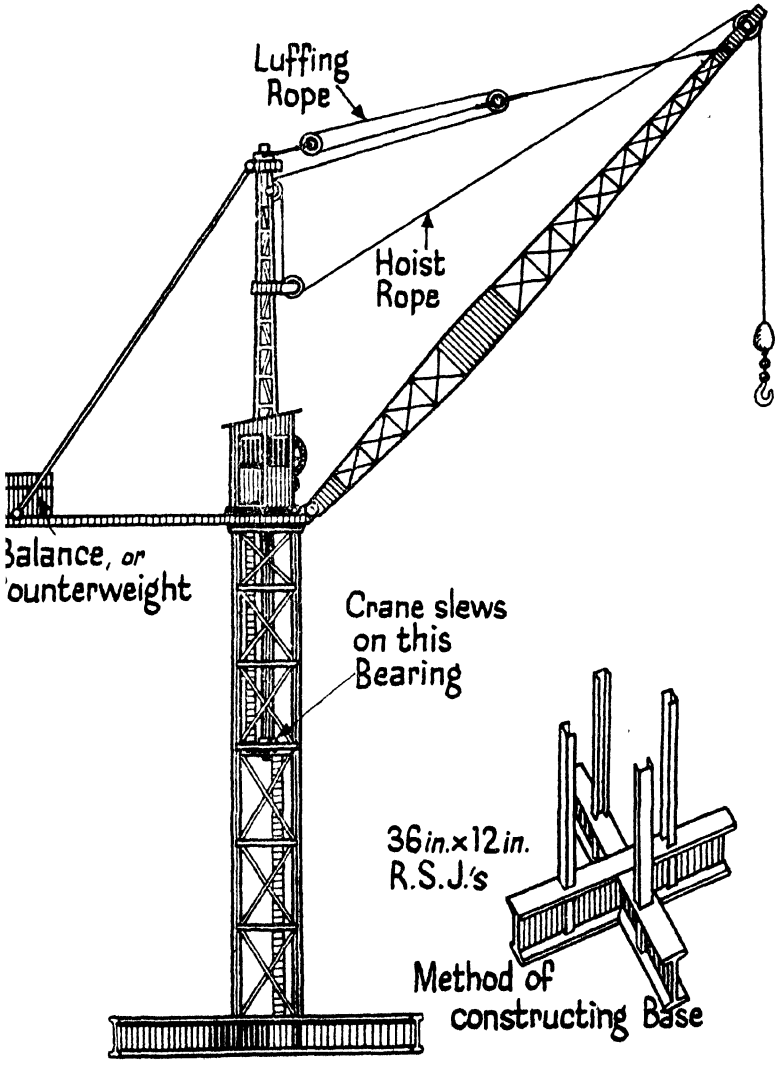
The object of the tests is to make sure that not only is the crane structure sound, the ropes safe, and the slewing, derricking and hoisting gears in order, but to be certain that the anchor weights are sufficiently heavy.

In the first part of the test the crane lifts its normal load and lowers it under the brake, after which they are repeated with an overload of 25 per cent. When we speak of a 5-ton crane, we do not mean that it will lift this weight at its longest radius, it will not. The makers always supply a chart showing the safe loads at various radii. The engineer will get together loads of rails, steel piles, or piling monkeys, of which he knows the weight to within a few pounds or so, and these will be lifted at the correct radii ; meanwhile, the inspector stands waiting for the anchor weights to lift. It is rare indeed for the tests to find anything wrong however, for no man using derricks will ever take any chances, but there are times when a derrick on bogies pushes the mast bogey rails down into the ground a few inches. This is not altogether surprising, as a little diagram work will show the load to be considerable.

Suppose we add up some of the items. First we have the weight of the bogey, which will be about a ton. Then there is the weight of the mast and cab with its motors, gears and so on, another 10 or 12 tons ; the test load of 7 tons ; finally the reaction from the two 10-ton anchors. This brings up the actual pressure on the mast bogey to about 40 tons. The bogey wheels have a short base, so this load comes on to a comparatively short length of ground. For this reason, crane loads are often built on long " whole " timbers, 12×12 inches,—to distinguish them from " half " timbers which are 6×12 inches section.

There are other forms of derrick cranes, often seen in the cities, where space is limited. One of these is the Mono Tower

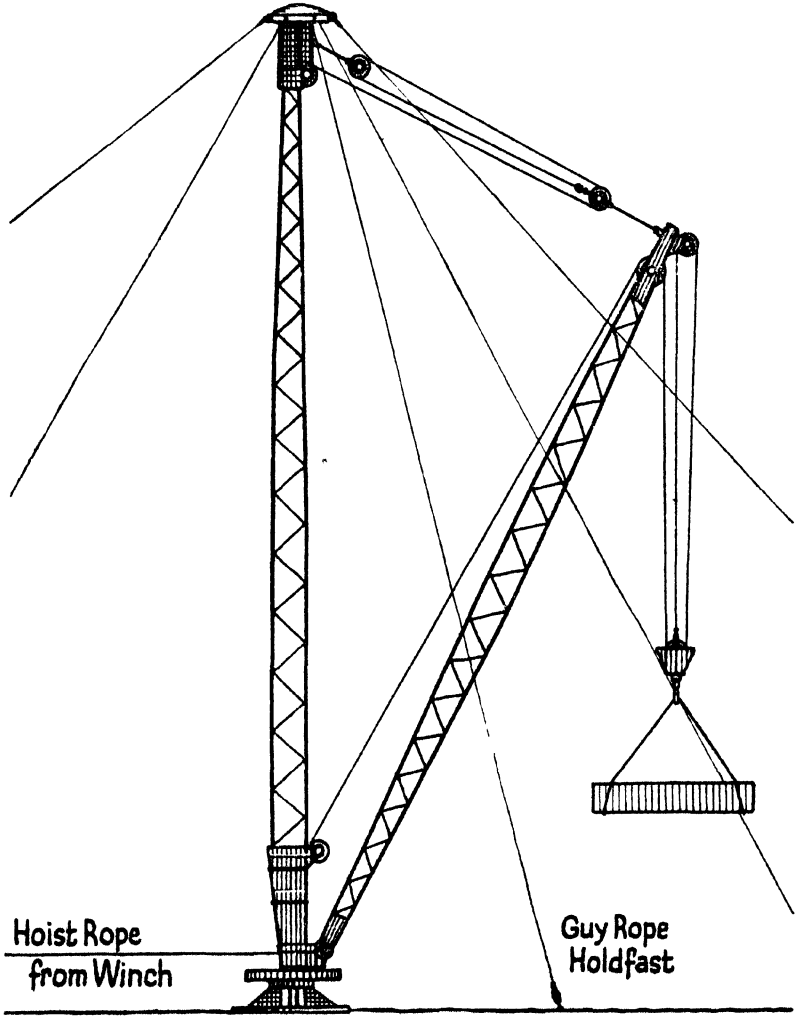
type illustrated below. Though it looks sensational, it is really quite safe, perched atop of its single supporting tower of steel framing. Viewed from a distance this looks to be slender in construction, but a close-up view shows it to be built up of



The Mono-Tower Derrick does away with the necessity for a heavy timber gantry. Its base occupies very little space, and the crane gives all-round service.

12 inch channel as to the tower legs. Instead of raker legs, it has a counter-balancing arm with a load, the whole assembly turning with the mast, and giving full-circle service.

The All-Round Guy Derrick is much used in the erection of steel framed buildings as it requires very little space, but, like the tower type, it must have good ground for its base to stand



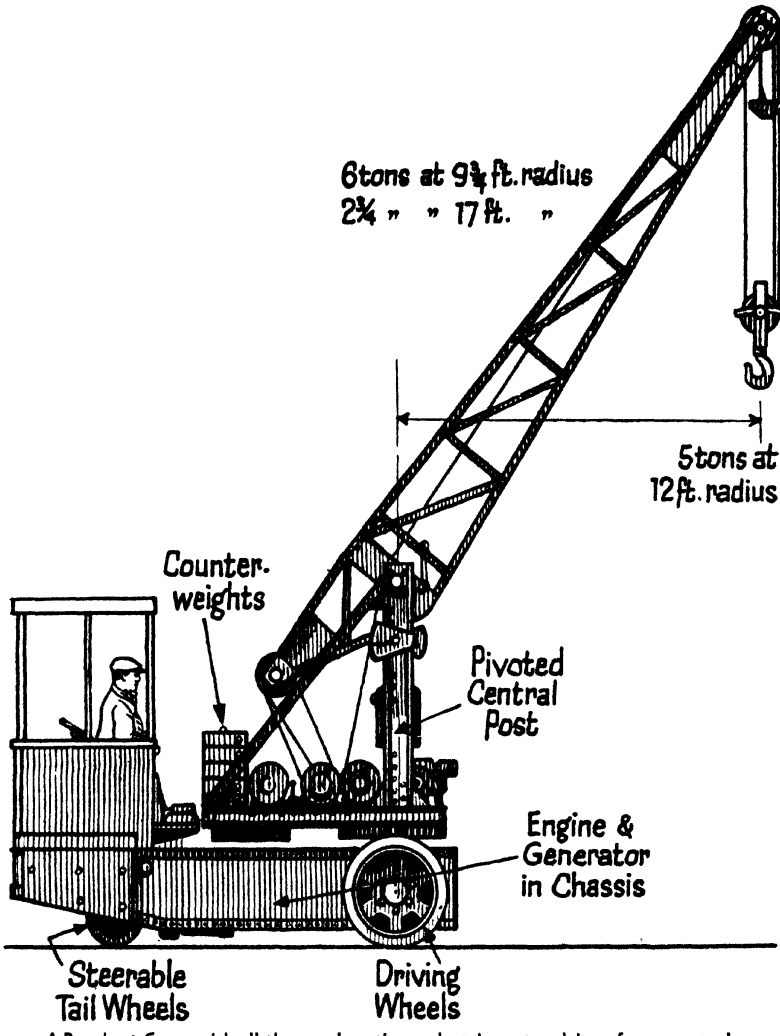
The All-Round Guy Derrick is much used in the erection of steel-framed buildings, where the minimum of room for a crane base is available.

upon. In this case there is a lattice steel king-post, guyed with steel ropes, and a jib pivoted at the base of the king-post, which will be higher than the jib. As erection of the building progresses the frame can be brought up higher to be set on the steel frame it has already assisted to put up. At one time these cranes were regarded with some dislike by the erecting gangs, but the modern types have overcome all prejudice. They can be worked by hand-winch, as in the smaller types, or with power from any preferred source. We have seen one of these in a quarry handling 20-ton blocks, with a steam engine to do the work. Such a crane would have a maximum radius of action of 45 feet, but the load handled at this radius would be limited to about 5 or 6 tons. The winch can be situated at any reasonable distance, the rope being guided by well placed snatch-blocks.

This type of crane is probably the development through the centuries of the oldest form known in history, for there is an interesting bas-relief in the British Museum showing a Roman crane just like it in principle. Instead of the steam engine, the power is supplied by slaves in a treadmill !

The runabout type of crane has come to the front a good deal in recent years. This is easy to understand to anyone who has had one in use, for they will go almost anywhere, being mounted on heavy pneumatic tyres—or alternatively solid rubbers. Made in a considerable variety of sizes, load capacities from 1 ton to 6 tons, the power is provided by petrol or diesel engine driving an electric generator at constant speed. The crane motions are carried out by separate motors, with a well arranged system of automatic control, limit switches are provided to guard against all the possibilities of overwinding and the like. The driver has only to pull a small lever for the particular motion he requires, then putting the motor to work by means of a pedal. Should anything take his attention away, he can be quite sure that whatever happens, no damage will come to the machine.

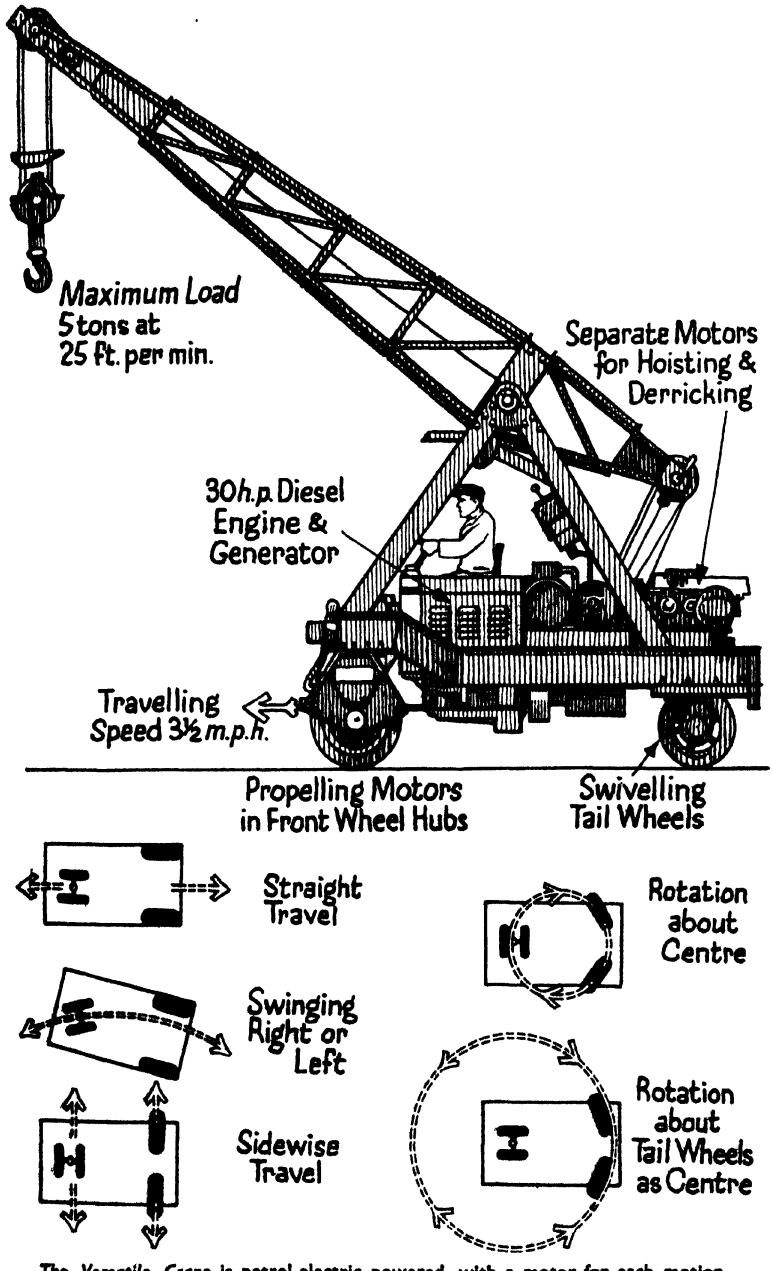
A 6-ton crane of this sort will have a 30 h.p. engine, and can handle the maximum load at a radius of 9ft. 9ins. and 2¾ tons at 17ft. The arrangement of the swivelling wheels provides an infinite variety of movements with the load—a few of these are illustrated in the drawing. This is the versatile variety. The mobile type is not so free as to its travelling movements, but it



A Runabout Crane with all the usual motions, electric motor driven from a petrol-electric unit in the chassis. Hanging from the jib can be seen the automatic safety device to prevent overwinding.

has a slewing motion, the crane being pivoted on the carriage, thus it has all the advantages of any other crane together with a great freedom of action.

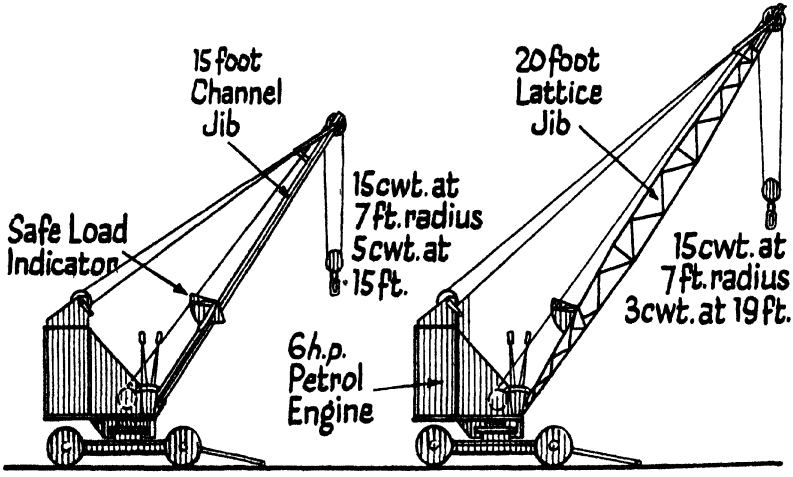
These cranes prefer well-made ground to work upon, so they would hardly appear on the virgin site of our big contract job



The Versatile Crane is petrol-electric powered, with a motor for each motion. Some hints as to its freedom of action are indicated below.

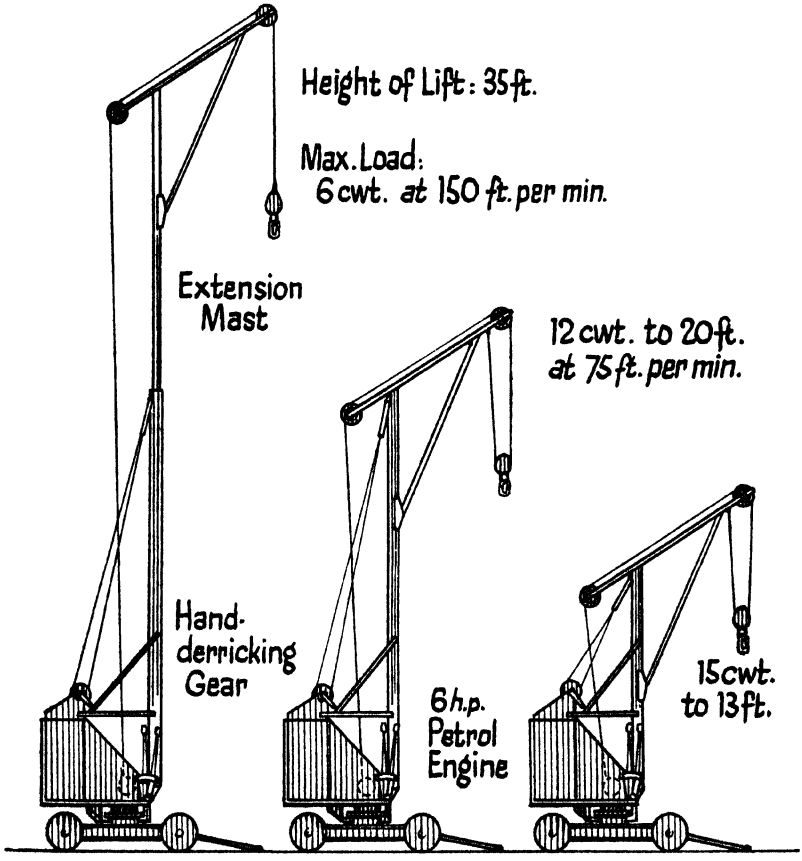
at first. Their value in the stockyard is enormous, handling materials from wharf or in the railway sidings with the utmost facility. The front wheels—those below the crane itself—are the drivers, each having its own motor, so the traction is actually increased by a load. With a 6-ton load, on good ground, the maximum speed for travelling can be about 3½ miles an hour.

So simple is the control that even an amateur, so long as he knows something about what he is doing, can get the idea in a very few minutes. The writer is quite sure of this because he has tried. Admittedly crane-driving is an expert job, but these machines make it seem an easy one.



The uses to which a mobile crane can be put are so numerous that it would have been surprising indeed had there not been a really small machine put into service. So we finish up this chapter with some notice of one of these, the Rapid crane seen almost everywhere today, performing what look like herculean tasks right on the spot, perhaps on city street pavements, perhaps out in the field with a plank or two by way of ground support. Formerly these little cranes were built down to a load limit of 6 cwt., but these we are told are now obsolete, though there must still be many of them in service. With a

compact engine and winch gear enclosed completely in a square box no bigger than a post office pillar box, a variety of jibs, and a general simplicity of design, the observer might doubt their capacity for the job—until he has seen it work. A variety of mountings is available, and screwjacks are provided at the corners to lift the machine off its wheels should that be desirable. Such refinements as an automatic load sustaining device, and



Three sizes of mast jib are available for this little crane.

power operated slewing gear are incorporated also. A page of drawings to show some of the features of these excellent cranes

is given here. This shows a few of the possibilities that the different jib arrangements permit, though the observant passer-by will have seen these and others for himself almost everywhere that public works are in progress.

Chapter 5

EXCAVATORS.

THERE can be little argument that the most useful of all the contractors' tools is the Excavator, usually called a navvy or digger, for without it hardly any of the enormous factories and aerodromes which have been constructed in the last few years could ever have been commenced, let alone finished.

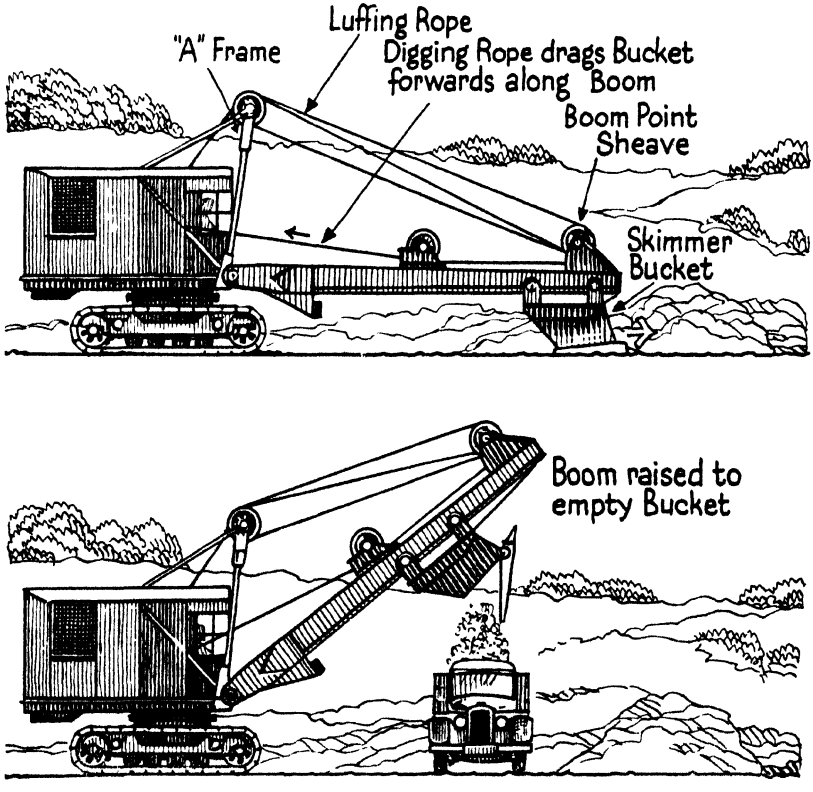
First introduced into this country from America in 1887 to work on the Manchester Ship Canal, they were a source of wonderment to the people of that part of the country and trips were organised to provide a view of the " American Devils " as they were popularly called. So well did these somewhat crude machines perform, however, that the idea caught on, in spite of the understandable outcry on the part of the labouring fraternity who could see their living about to disappear. Such has not been the case, very far from it.

When it is realised that a fair-sized Excavator can dig a thousand cubic yards of earth in an ordinary day's work, it will be seen that a job that requires ten of these machines working day and night for three months would need hundreds of thousands of labourers if it were to be completed in two years. Today we plan a factory, expect, and usually get the whole thing built and in production in a matter of weeks only.

Roughly speaking a navvy consists of a power-operated shovel mounted on a creeper undercarriage, but there are so many different kinds of soil to be dealt with at various times that the actual shape of the shovel and the way in which it tackles the digging have to be designed to meet conditions. The actual machine is always described as an equipment, and

as we shall see presently they vary considerably not only in size but in type.

In this country alone there are at least five different makers of excavators, each making perhaps six sizes of machines, each size being built with six different kinds of equipment. As a result, even experienced men become confused between one and another, so we will commence by describing a simple form of equipment as fitted to a medium-sized machine—before going on to the more complicated types.



The Skimmer Equipment in action. Digging is done as the bucket is drawn outwards from the cab.

The drawing shows a navvy fitted with Skimmer equipment. Mounted on two crawler tracks is a cab containing a powerful diesel or petrol engine driving sets of gears and rope drums—which we will deal with presently. Hinged at the front end of

the cab is a jib, better described as a boom which can be raised or lowered by means of the ropes passing over the grooved pulleys seen at the front end. The inner ends of the ropes are secured and wound on to drums outside the cab.

The boom is fitted with flat steel rails along which runs the skimmer bucket. This is fitted with bronze-bushed steel rollers running on steel pins, and the rollers are so arranged that the bucket cannot move up or down, only along the boom. Flat steel blocks are used as rubbing pieces to prevent any side play.

If the boom is raised, the bucket will run backwards along it towards the cab ; to move it forward again a rope is fastened to it, passed round a grooved pulley at the front end of the boom, and so back inside the cab to yet another rope drum. By turning this drum the bucket can be drawn forward, and if the boom is lowered to the correct position the front lower edge of the bucket will cut into the ground, digging up the soil and so filling it.

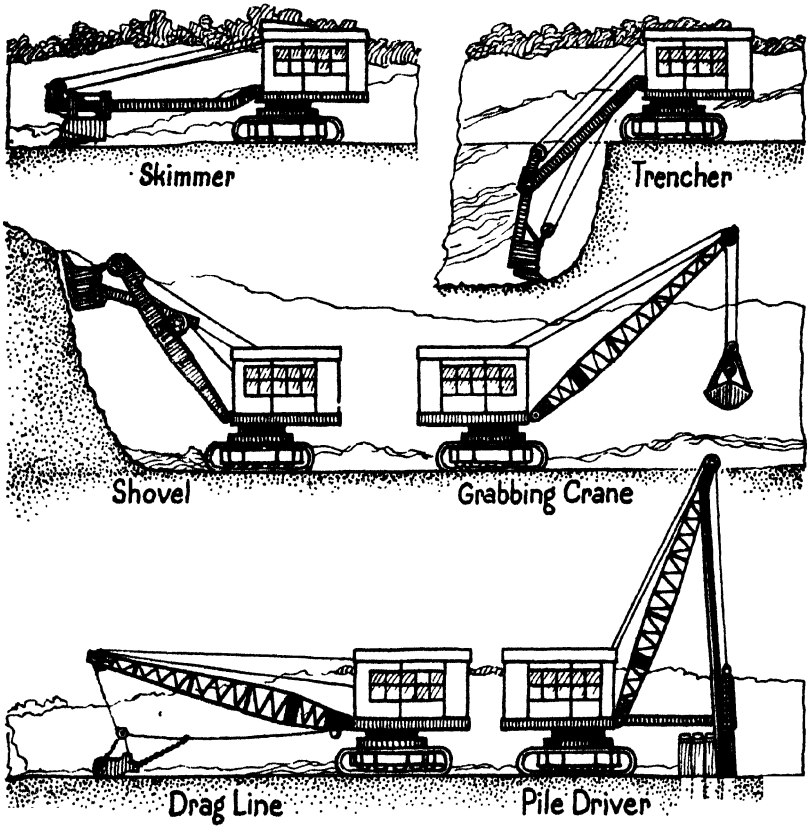
The boom is now raised, the cab slewed round to any required position, perhaps to bring the bucket over a waiting lorry, and the bottom of the bucket, which is really a hinged floor, is opened by a release cord, thus dumping out the spoil.

To move the machine along as it completes its cutting, the creeper tracks are made to unroll themselves in front or to the rear, according to whether the machine is to run forwards or backwards. For this reason such machines are called track-layers, their chief advantage being that they support the weight of the navvy on a large area, thus reducing the tendency for the whole outfit to get bogged in soft ground. A 20-ton navvy would in this way have about 20 square feet of support, as against the few square inches of a wheeled vehicle of the same weight.

Now that we have some idea as to what this machine does, we can commence to find out how it works, a task which seems at first glance a trifle difficult when we climb up into the driver's seat, to be confronted with nine levers, three pedals, and a number of smaller knobs, each of which quite obviously does something important.

The skimmer is only one of a number of equipments built around the navvy mechanism. Besides this there will be—or can be if the contractor wants them—a Trencher, Shovel or

Excavator, Drag Line, Pile Driver and Grabbing Crane. External modifications are necessary, and ropes have to be reeved in different ways for each of these, but the heart of the equipment is the same, the machinery in the cab remains. So, if we look at this we should learn something about them all.

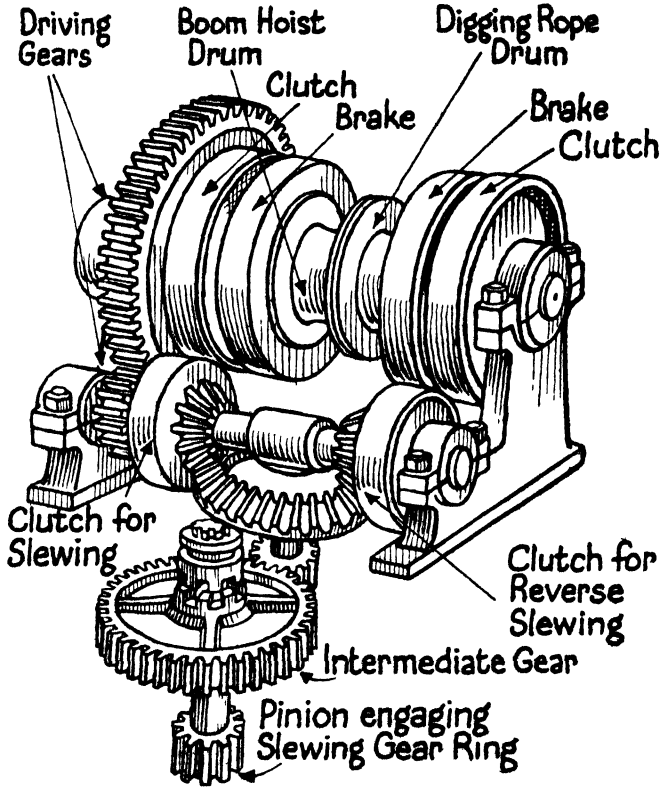


Most equipments are able to provide these six machines by changing the boom and its gear as well as altering the reeving of the ropes.

First of all, here for simplicity's sake is a set of gears from an older type navvy, chosen because they are more simply arranged than some of the more elaborate modern machines. Details of the engine have been omitted, though the position of this important item can be clearly seen in the sketch on page 92.

Near the front of the platform, carried on two side bearing frames is a heavy steel shaft, running in large phosphor-bronze

bearings—more usually ball-bearings now—adjusted like those of a motorcar engine by means of thin metal leaves known as shims. Each bearing is fitted with a nipple to allow the application of a grease gun so that it can be kept adequately lubricated.



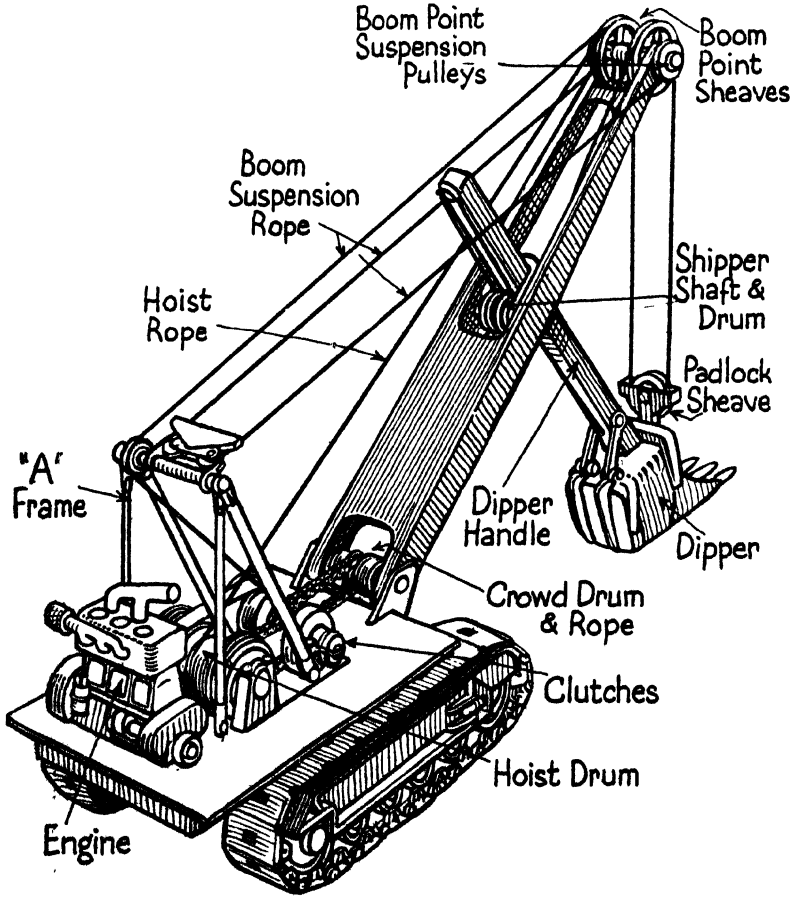
A simple set of gears from a Navvy Equipment.

Running freely on the shaft are two rope drums, each being quite free to turn independently of the other, but attached to the drum sides are friction drums, which are really large clutches that can be engaged or disengaged by means of two of the driver's hand levers. When engaged they are coupled firmly to the shaft. Alongside the clutch drums are brake drums, with steel Ferodo-lined bands encircling them, capable of being tightly clipped by means of the driver's foot pedals. These

are of course anchored to the platform.

One end of the shaft is fitted with a toothed wheel which takes the drive from the engine through yet another clutch. These clutches are powerful external-expanding affairs, made to hold solidly when engaged, with a toggle arrangement to expand the friction band.

If the boom hoisting rope be fastened around the left-hand drum, it will only be necessary to engage the clutch on the drum to raise the boom, or to disengage it and with the help of the foot brake to lower it to any required angle.

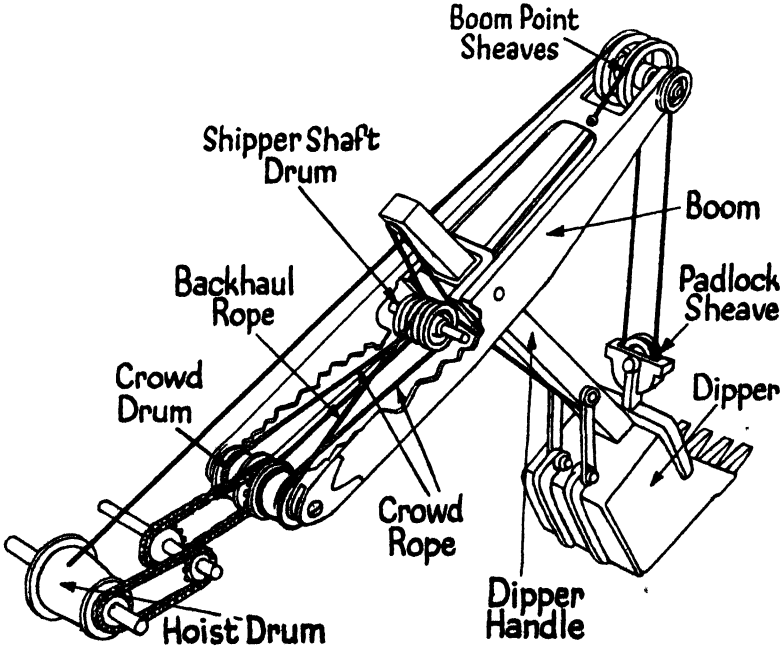


The essential details of an Excavator, with Rope Crowd gear. All control gear has been eliminated.

Rising from the floor of the machine above the drums is an A-frame with a jockey pulley which carries this hoist rope from the top of the boom to its rope drum.

The other drum takes the rope that can be called the digging rope, for in an excavator it is the one that drags the digging bucket up the face of the bank that is to be cleared. With the skimmer equipment it drags the bucket along. In the case of the excavator it passes over a sheave at the boom point, then down to the " padlock " sheave attached to the dipper arm ; then, returning over another sheave at the boom point is secured on the boom frame.

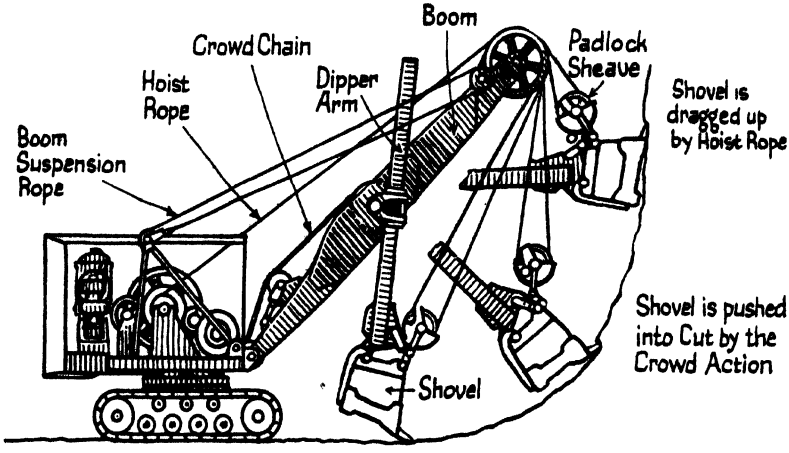
The excavator bucket, or dipper, is mounted on a long arm, with its other end passing through the large hole cut in the boom. A rack is cut on this end of the arm, engaged by a pinion turned by a drum on which wire rope is wound. Turning the pinion drives the rack and dipper arm forward—or withdraws it. Pushing it forward forces the teeth of the dipper into the soil to be cut ; this motion is called " crowding."



The working of a Rope Crowd can be followed from this drawing, as well as the reeving of the Hoisting Rope.

There are other methods of doing this; a usual form is by means of a rope wound on the crowd drum, driven through a clutch by the engine. The reeving of this rope is a little complicated, but it can be followed, with its action, from the sketch. Going back to the first system, the wire rope is wound on or off by a chain drive from a clutched shaft.

Every maker has his own ideas as to the best way of arranging this part of the machine, of course, but we can only deal in general principles here.

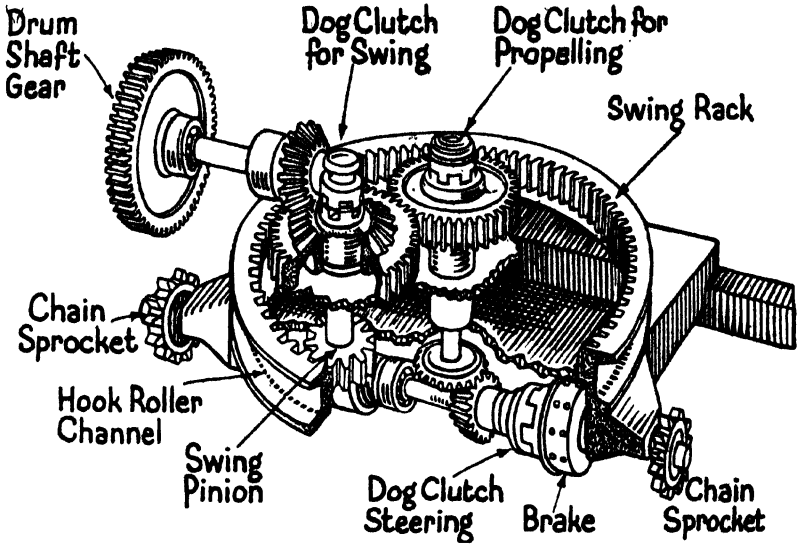


The action of an Excavator Equipment with Crowd Action.

Back now to our machine platform, we have to see how slewing and travelling are arranged for. Just behind and below the main drums a pair of bevel wheels can be seen, each of which can turn on a shaft independently of the other, each having its own clutch drum. By means of these clutches, either bevel can be made to turn, and as both engage with the bigger bevel wheel below, this will be rotated in either direction according to the clutch engaged by the driver.

Below this bevel wheel is a small toothed pinion keyed to the same shaft, and arranged to gear with a larger wheel—the intermediate gear—running freely on a short vertical shaft passing through the floor of the excavator. It has a dog clutch on splines so that it can be clutched positively to the shaft, whilst below the floor this latter carries a pinion to engage the teeth of a four-foot diameter gear ring known as the slewing gear.

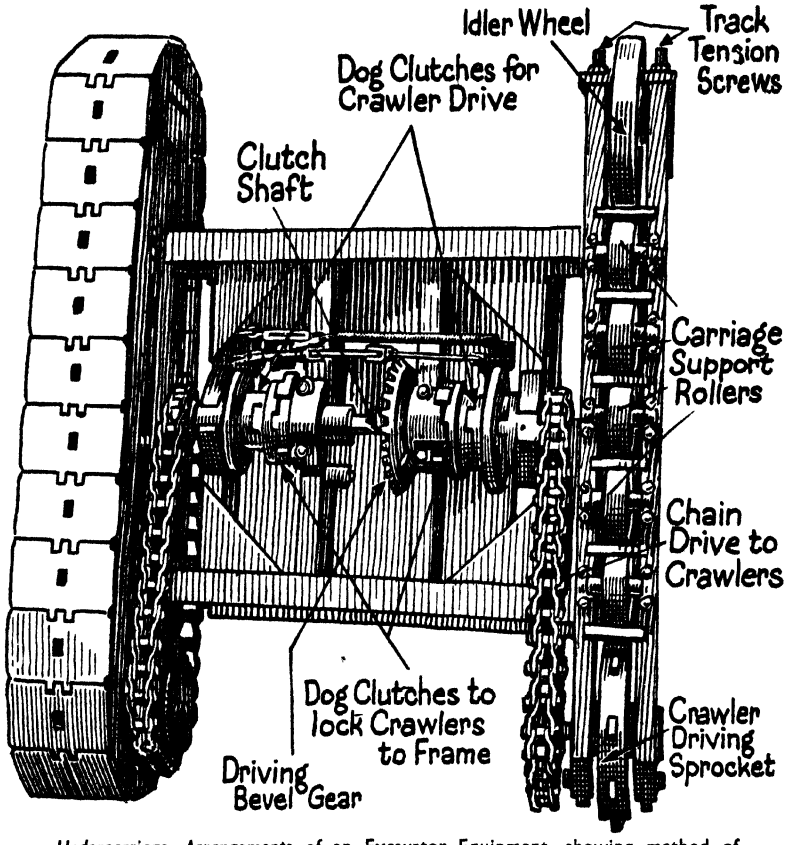
This gear is mounted solidly on the frame of the travelling carriage to which also the pivot pin, on which the machine slews, is rigidly secured. Clearly then, turning the small pinion swings the machine round, and engaging one small bevel pinion or the other slews it one way or the other.



The sequence of gears and pinions in the Swing (or slewing) and Propelling of an Excavator. Note how the propelling shaft passes through the central pivot.

Not shown in the drawing are another set of gears provided for propelling the whole equipment in either direction through two heavy chain sprockets that drive the actual creepers. Reference to the sketches of two undercarriages show the clutching action that separates one or the other creeper-driving sprockets from the driving bevels, clearly shown therein. These are dog-clutches, sometimes engaged by means of a lever in the cab, and sometimes by levers down near the front of the machine, where they can be worked by the driver's banksman.

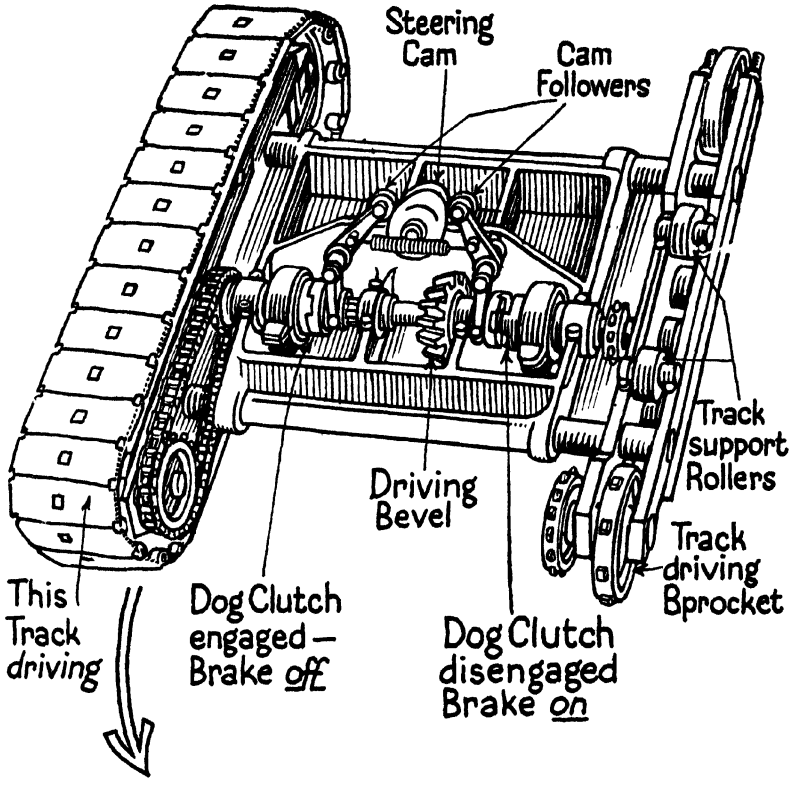
The engine for a small excavator, able to dig out half a yard of muck at one bite, will be of about 35 h.p. or so ; probably a diesel, much the same in detail as those found on heavy commercial vehicles. As excavators generally work in a cloud of dust and dirt, careful filtering of air is necessary, to remove the



Undercarriage Arrangements of an Excavator Equipment, showing method of driving and steering.

destructive grit that would soon grind away the best interior arrangements in quick time.

An engine of this type and size can be started by hand, but will have some assistance from what the driver calls " squibs." These are about the size of a cigarette, and being made from a blotting-paper-like substance soaked in chemicals they smoulder slowly when lighted. They fit into the ends of screwed stems which can be fitted into the cylinder heads by means of an instantaneous screw thread. Having lit the squibs, the driver screws them in place, sets the fuel pump lever into the Start position, and then with the help of his mate swings the starting handle as hard as he can.



Steering Arrangements for an Excavator Equipment. A cam controls the engagement of dog clutches transmitting the drive to the Crawler Tracks.

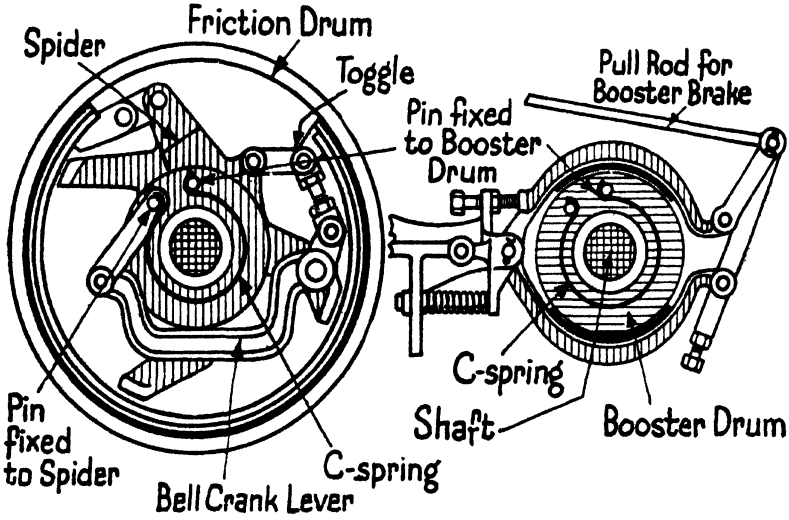
On a cold morning it may be necessary to use two or more squibs to get the engine warm enough to kick off, but such occasions are rare, provided the pump and injectors are in good condition. We ought to say, of course, for the benefit of those unacquainted with the diesel engine that these difficulties arise on account of the very high compression of engines of this sort.

Modern machines, especially those of the larger sort have small petrol engines to do the work of starting. Others have electric starting motors driven by accumulators charged by dynamo driven by the main engine while it is at work, just exactly like a motorcar.

Excavators run through a variety of sizes, right up to

enormous machines that can dig out 11 cubic yards. These giants are employed at such work as stripping out the ore or coal in open-cast mining. We have some such at work in this country, but generally speaking the most useful sizes for our contractors do not much exceed the 1 cubic yard size. Their engines are proportionately more powerful, obviously.

Some years ago navvies were all steam driven, but the inconvenience of getting good water to their boilers, the periodic stoking of the fire, and the tendency to " lose their puff," that is, shortage of steam, when doing a long spell of hard digging, has resulted in their replacement by internal combustion units. The old steam engine had a wonderful power of hanging on, provided its steam supply was adequate,



Details of a Clutch with power assisted operation. The two details have been separated though they are on the same shaft.

and it would work when in a positively shocking mechanical condition, so many were sorry to see its passing.

If you were not used to them, navvy engines would worry you perhaps, for they have a dreadful " cackle," entirely different from the sound of even the largest lorry engines, but the accustomed ear soon detects whether it is the right kind of noise.

There are some details in the make-up of the larger sized

excavators that are of interest, particularly in the clutches used for the various motions. These have to be very robust and powerful in their action, so much so that it is not easy to control them directly by the driver's levers. So we make the engine do the work, and this is how it is done, at least in one way, for there are other ideas as in everything else.

Here are diagrams to illustrate two of them, though other clutches are illustrated elsewhere. In the first we find bent around inside the friction drum a steel band pivoted to an arm formed on the end of the clutch spider, which is shown separately in the drawing. On the outer face of the band Ferodo friction lining is riveted. The spider is keyed to the shaft so that when that turns it is carried round bringing the friction-lined band with it.

If the steel band can be expanded, the Ferodo will grip the inside of the drum, locking that to the spider and setting that in motion too. Now, on another arm of the spider a bell crank lever is pivoted, the long arm linked to a flat C-shaped spring, whilst this in its turn, has one end fixed to a small brake drum which is free on the shaft. The other end of the bell-crank lever is fixed to a pin protruding from the spider. If the small brake drum is twisted round to the left, the bell-crank lever will turn on its pivot and its short end will move upwards.

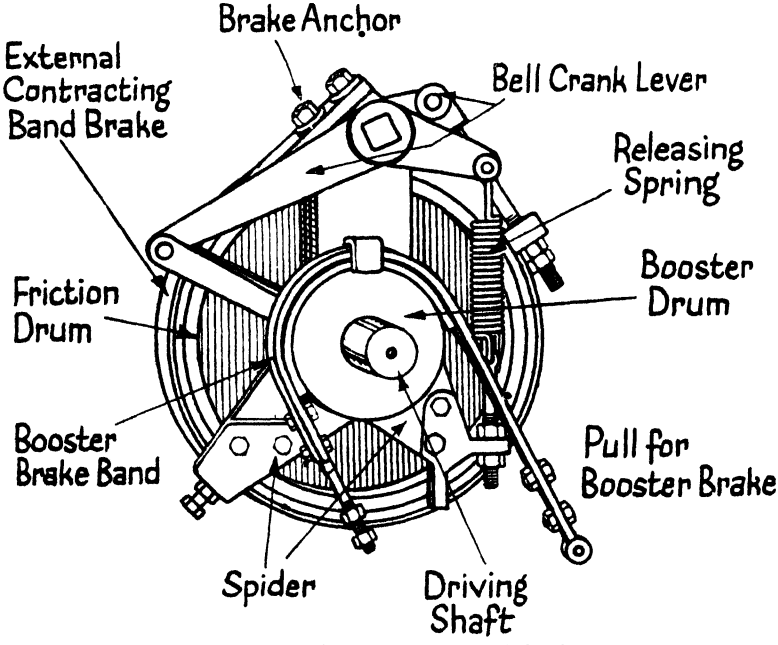
Linked to this short arm by an adjustable screw is the other end of the steel friction band, and a toggle link, the resulting action being a powerful expansion of the band and a strong grip of the friction drum.

When the machinery is on the move, we, cannot, of course, apply the movement required to the small brake drum by hand, so a booster brake is put in to make the engine do it. Here are two half-round shoes lined with hard fibre pivoted at one end to a bracket on the side frame of the machine. The other ends are connected by an adjustable toggle-link which is so made that a long movement of the long side gives only a small movement together of the booster shoes. In other words, a powerful leverage effect, so that a light pull on rods connected to the driver's hand lever produces a strong grip of the shoes on their drum.

By closing these shoes, we tend to check the drum they grip and cause the booster brake drum to turn a little relatively to

the spider, thus expanding the steel band and engaging the clutch.

The action of the second clutch illustrated is very similar and should be easily followed if the explanation of the first has been understood.



Details of another power operated clutch.

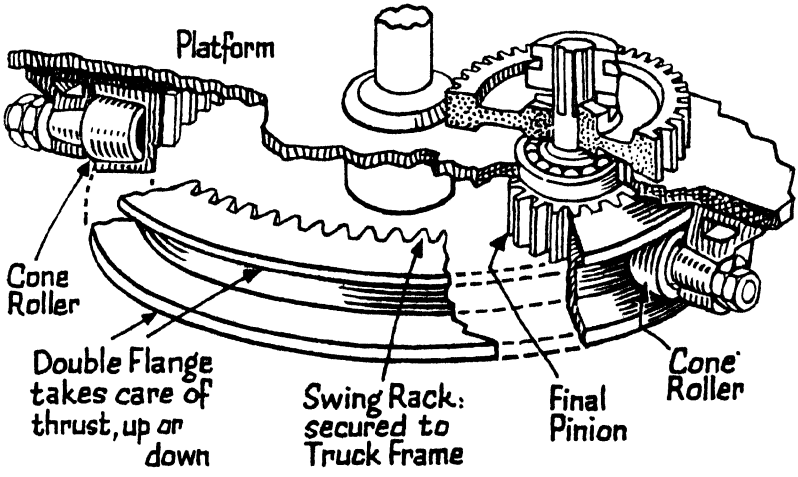
It all seems very elaborate, but it must be remembered that these machines are the result of very concentrated development over a period of years, and it is not likely that elaborations would be put in if they were unreliable or unnecessary.

When a big navvy digs there is a tendency for it to overturn so that the pivot about which it slews has to withstand tremendous stresses. With the idea of helping the pivot, use is made in some machines of hook rollers, illustrated in a broken-out drawing here.

On top of the crawler undercarriage is a steel channel section ring, and hanging below the revolving frame of the machine are three brackets carrying conical rollers which run snugly inside the channel. As the machine slews, the rollers

run round on their pins but they keep it from rocking up and down. Thus the main work of the pivot pin is to keep the revolving frame central.

This very brief description of some of the main parts of the navvy, may be ended with a few notes about the digging bucket. This is just a hollow steel box with a hinged lid at the bottom



How the Hook Rollers run in the double-flanged channel to prevent overturning.

closed by a strong latch which can be released by a simple trip gear operated by a cord from the driver's hand. The lid slams shut again as the driver swings the dipper arm back to the position for commencing a fresh cut.

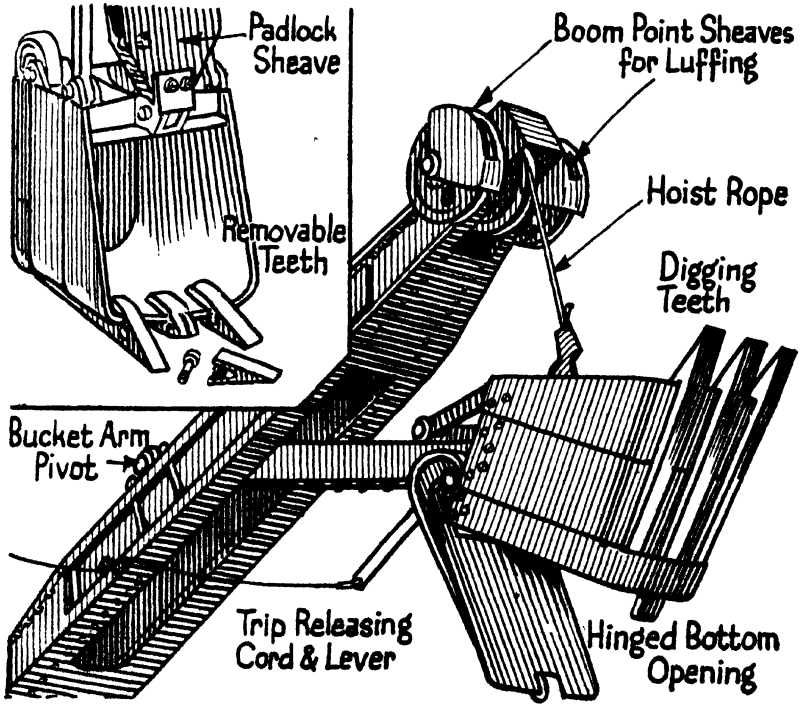
The digging action of the bucket depends on several massive wedge-shaped teeth, metal of the very toughest manganese steel. These are often made reversible so that they can be taken out and turned round.

There are, of course, hundreds of other parts in a navvy, and the plant engineer knows them all ! Properly looked after, an equipment should last for nine or ten years, but unfortunately the contractor's main idea is to keep them running at all costs, however much they groan and squeak for want of lubrication. The drivers, too, help in this mistaken view of how not to look after a navvy, for they are often paid bonuses on the amount of soil they can get out in a week. As a result they become extremely skilled in manipulating the levers, digging, slewing

and dumping like robots, paying little attention to the machine so long as it runs.

Bearings wear rapidly, friction drums are scored, gear teeth wear till they are razor sharp, and sooner or later there is a breakdown. Be sure when this happens it is some thing right inside the works, and when the machine is far away from the repair depot. To do repairs inside a well-lighted fitters' shop, with a heavy vice for holding parts is relatively easy, but out in the field is a different story. The parts may be very heavy, the cab is cramped so that it will slew around in a narrow cutting, and to get at a worm bush in the centre of the machinery means tearing half the navvy to pieces. Add to that the probability that it is raining hard—the plant engineer will be glad to have that job over and the outfit working again !

On occasions it is necessary to dig against a cliff-like face, as when going into the side of a hill, and here another equipment



The Luffing Boom Shovel has no Crowd Action, the bucket arm being pivoted to the boom.

may well be employed. This is the Luffing Boom Shovel—or Face Shovel. Luffing the boom of an excavator means raising it, and if a bucket is fixed to the end of the boom the luffing action will cut a curved face where it is working. The main difference between this and the shovel at which we have been looking is that there is no crowding gear, the inner end of the shovel boom or handle is pivoted to the boom proper. This is clearly shown in the drawing. It can be understood that its own weight brings the shovel back towards the navvy, any winding in of the ropes will force the bucket into the cut.

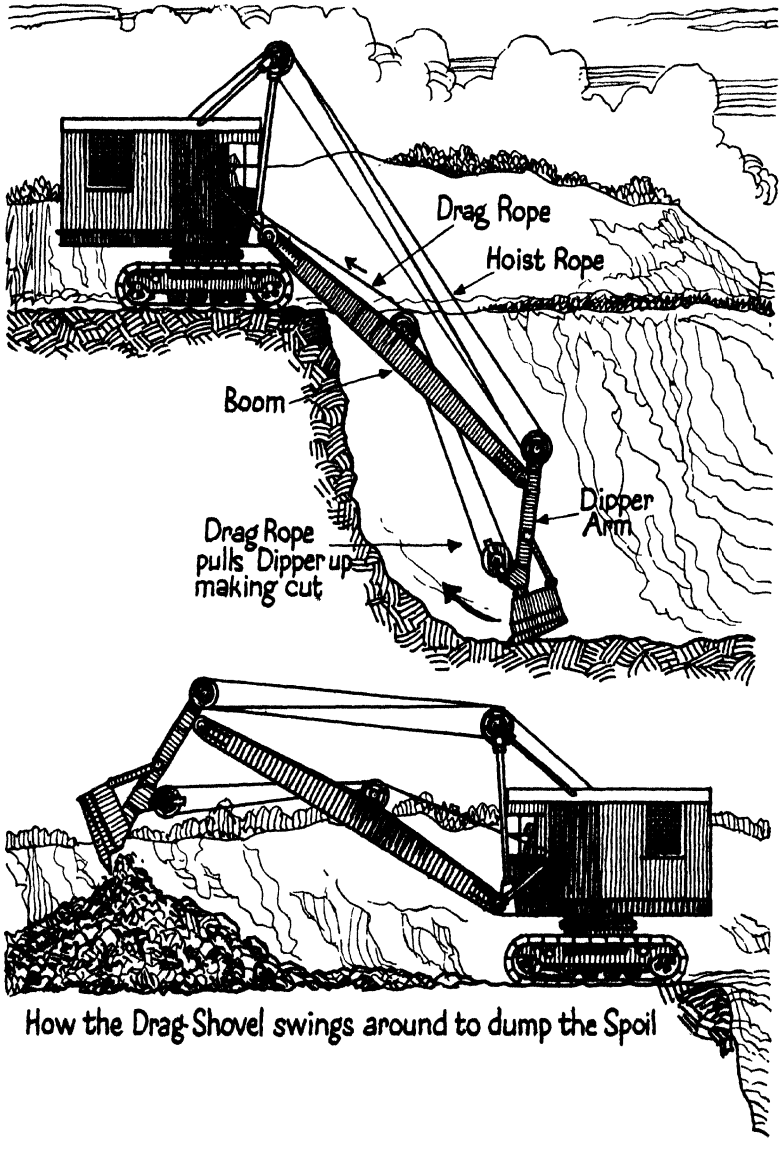
By considered use of the rope drum clutches the boom and bucket handle can be made to move together or independently, thus regulating the depth of cut. When full the bucket load can be dumped by tripping the bottom just as with the excavator.

Well then, the skimmer deals with horizontal surfaces, the luffing boom shovel with vertical ones, and the excavator with everything in between—what else is there? There is, for instance, deep excavation, unsuited to the skimmer. A large contract will almost always call for a number of long trenches, some of these quite narrow ones perhaps only a couple of feet wide for water pipes, drains and so on.

For these, the equipment known as a Drag Shovel or Trencher is employed. The skimmer boom has to come off, to be replaced by the one shown in the drawing. Here, the bucket, which cuts backwards towards the navvy, is fastened to the dipper arm, hinged at the far end of the boom. Pulling on the rope running over the sheave at the top of the dipper arm moves the bucket away from the machine, pulling on the other one draws the cutting teeth along the ground, so making the cut.

This motion being carried on, the bucket is brought up close under the boom, the machine being slewed, the boom is lifted, and the hinged bottom opened by the tripping of the bucket latch. Alternatively, the bucket can be brought back to the position for commencing the cut, when the spoil falls out by the way it came in. This process is clearly shown in the illustration.

A very useful improvement on the normal type of trencher is illustrated here. This is designed to cope with cutting of narrow drainage trenches, and for more expeditious working where the soil is of a sticky nature, a link-operated ejector is provided. Automatic in its action, this device clears the bucket

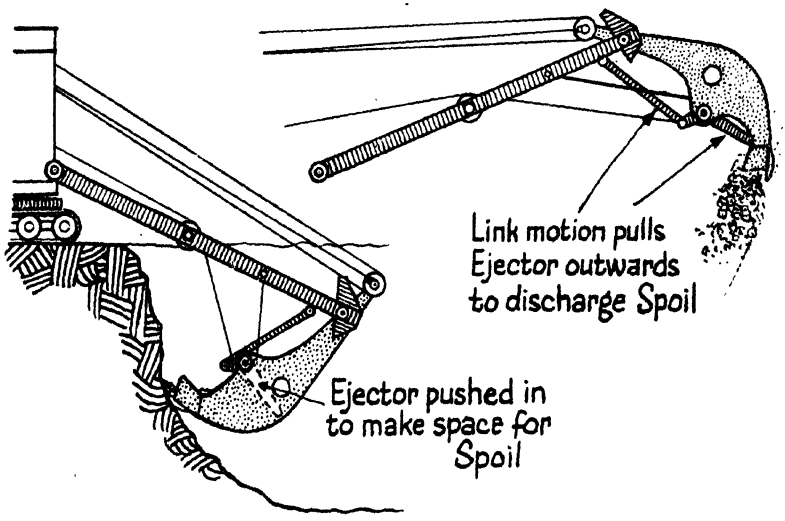


The Drag Shovel or Trencher Equipment in action. Its main purpose is to dig deep trenches.

with certainty in the discharging motion. Observe that this bucket is formed in one piece with its arm.

A small sized trencher will dig as deep as 18 feet, though this would be a maximum depth.

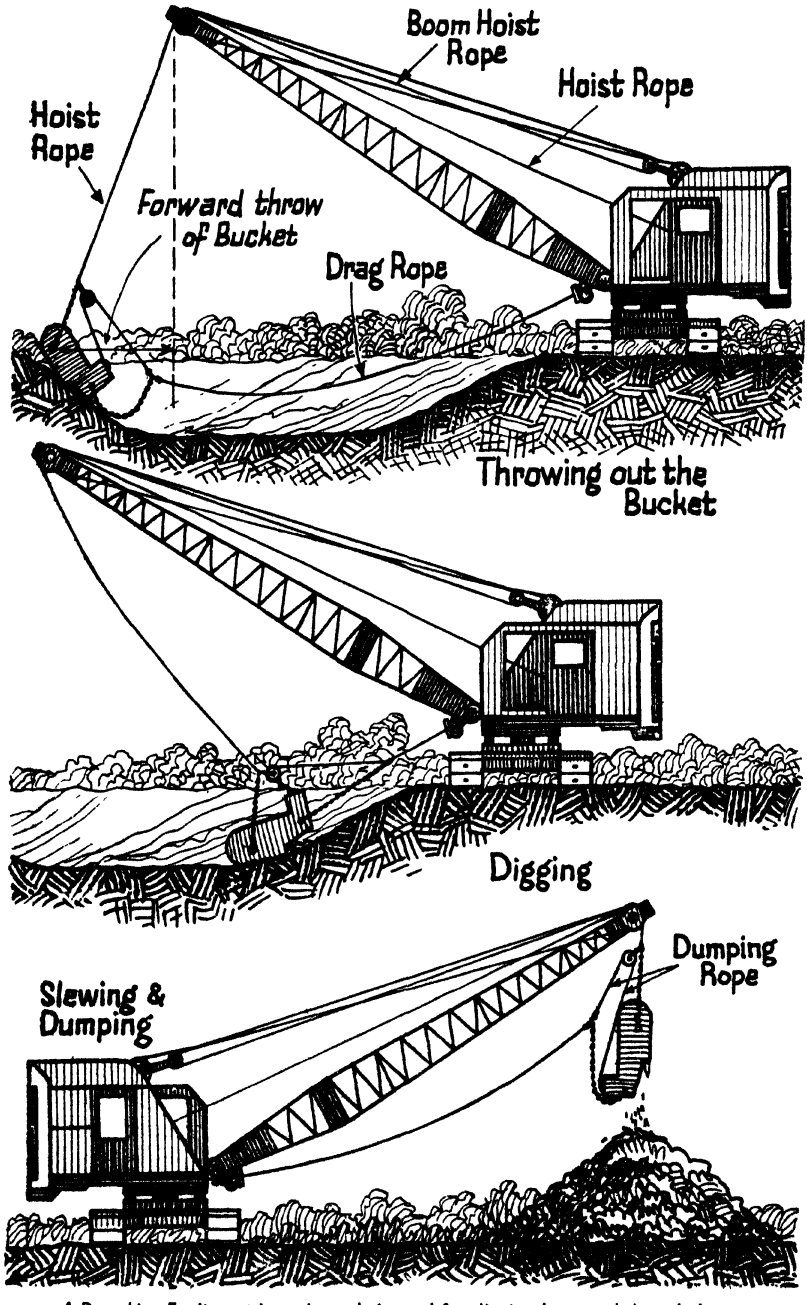
For deep holes use is made of a Drag Line equipment such



This type of Excavator digger has been devised for cutting very narrow trenches for Land Drainage tiles. It has a useful clearing device.

as is shown in the next drawing. The boom for this outfit is a long lattice work jib similar to those used on cranes. Ropes from the top of the jib pass over pulleys on the A-frame to a worm-driven drum set in the floor of the excavator. By means of a dog clutch this drum can be driven from the engine when it is necessary to raise or lower the jib. Usually this is set at a convenient angle and left in that position.

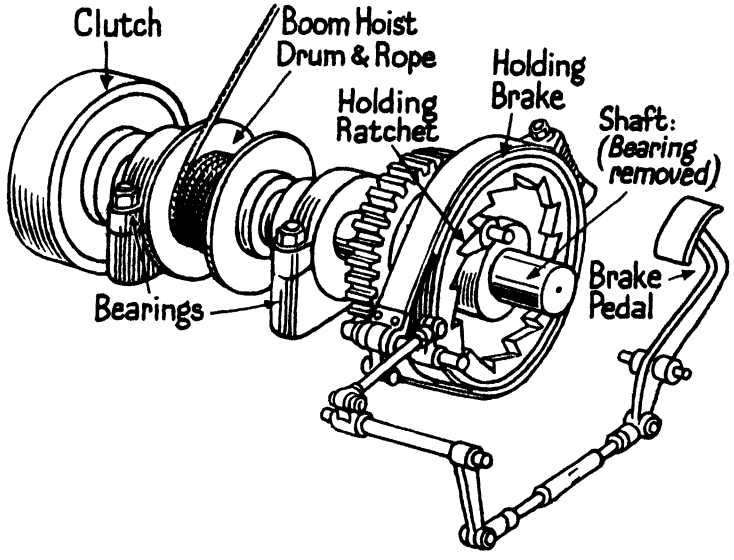
A rope from one of the rope drums passes over the head sheave of the boom and is fastened to a pair of chains from which hangs the drag bucket. This bucket has a second pair of chains at the front edge, and these are connected to a rope from the other rope drum of the machine. A wire rope—dumping rope in the sketch—keeps the two sets of chains connected in such a way that, the hoist rope drum being kept from turning by use of its brake, a slight pull on the drag rope,



A Drag Line Equipment in action. It is used for digging large and deep holes.

the one that pulls on the front bucket chains, keeps the bucket bottom level.

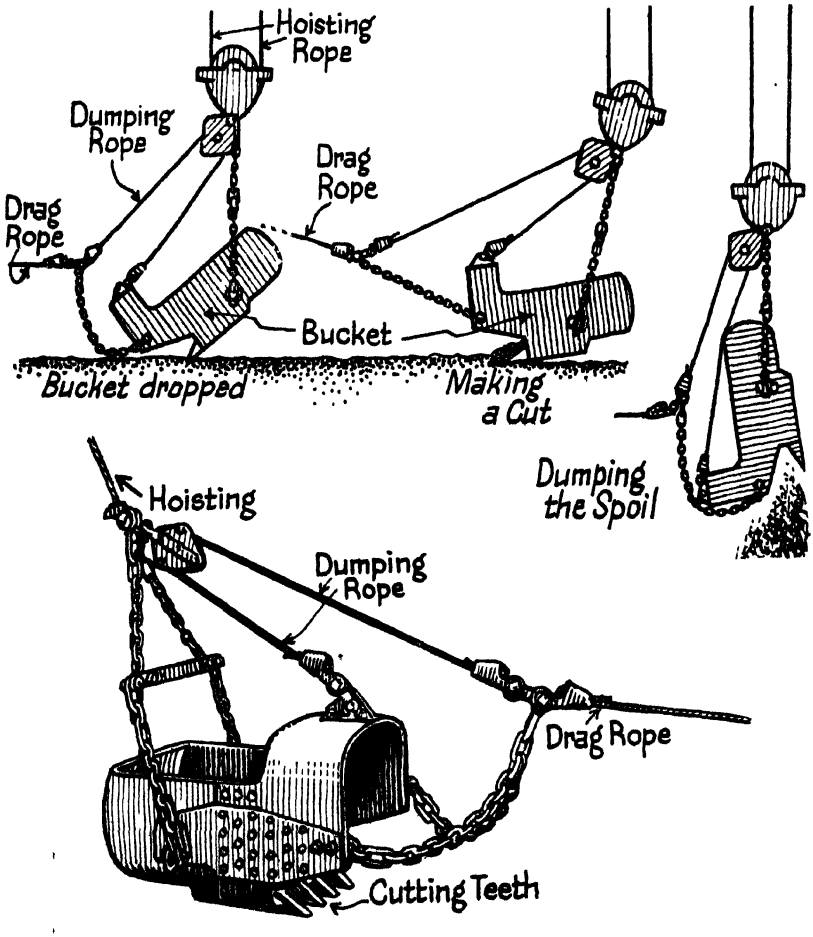
To dig with a drag line the driver slews the machine until the bucket swings outward. Releasing the drag-rope he allows the bucket to tip until its teeth are pointing downwards. Next



Brake details on the Boom-Hoist Drum shaft of any Equipment. A ratchet and pawl holds the brake on if required.

the hoist rope brake is released, allowing the bucket to fall till it digs into the ground, when, by careful manipulation of the drag drum clutch and hoist rope brake the bucket will fill with soil. When full, the driver keeps a slight touch on the drag rope brake whilst he works the hoist drum clutch to raise the bucket straight up into the air. He can now slew the machine until the bucket is over the required spot for dumping, let go the drag brake, which causes the bucket to tip about the hoist chains. This process may be clearer on reference to the drawings.

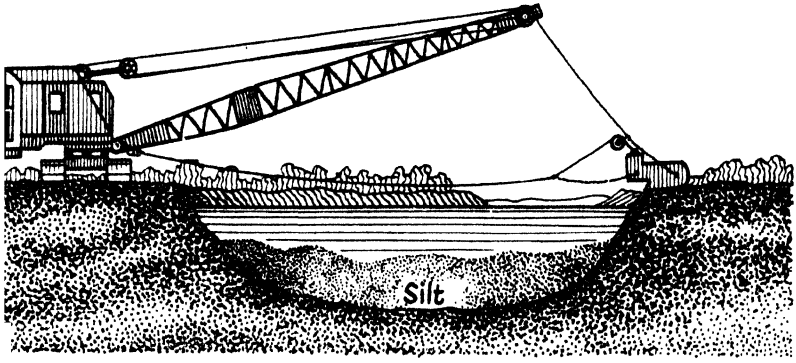
It all sounds somewhat complicated, but a good driver can dig, slew, dump, slew back and drop his bucket ready for a fresh bite all in half a minute. What is more, by skilful handling, he can throw his bucket out ahead of the jib perhaps another 30 feet or so.



The Drag Line Bucket in its three principal positions ; below, the usual method of attachment.

It says much for the machines that they can stand this constant slew and reverse for so long without breakage, especially when fitted with large buckets holding a ton or more of soil. Such a load swinging at the end of a 50 ft. jib can accumulate an enormous impetus. Drivers, however, get so used to their work that they start easing the slew before it gets out of hand, and in the same way they balance the bucket between the drag and hoist ropes so skilfully that they can strip a three-inch layer off the bottom of a cutting, leaving only slight tooth marks to show where they have been at work.

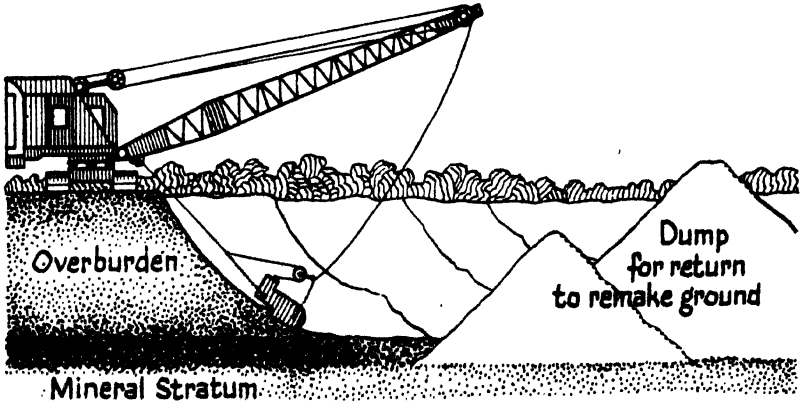
One difficulty with drag-lines is to discharge the spoil into skips or dumpers, because these make only a very small target for the driver to aim at. For this reason, if the spoil has to be dumped much further back than the swing of the jib will allow, then they do "haymaking" as they call it, a second machine being put in to work behind. The first one dumps the soil as



The Drag Line is a most useful appliance for cleaning out silted river beds, and improving drainage channels.

far as it can away from the cut, and the second one picks it up to swing it over still further.

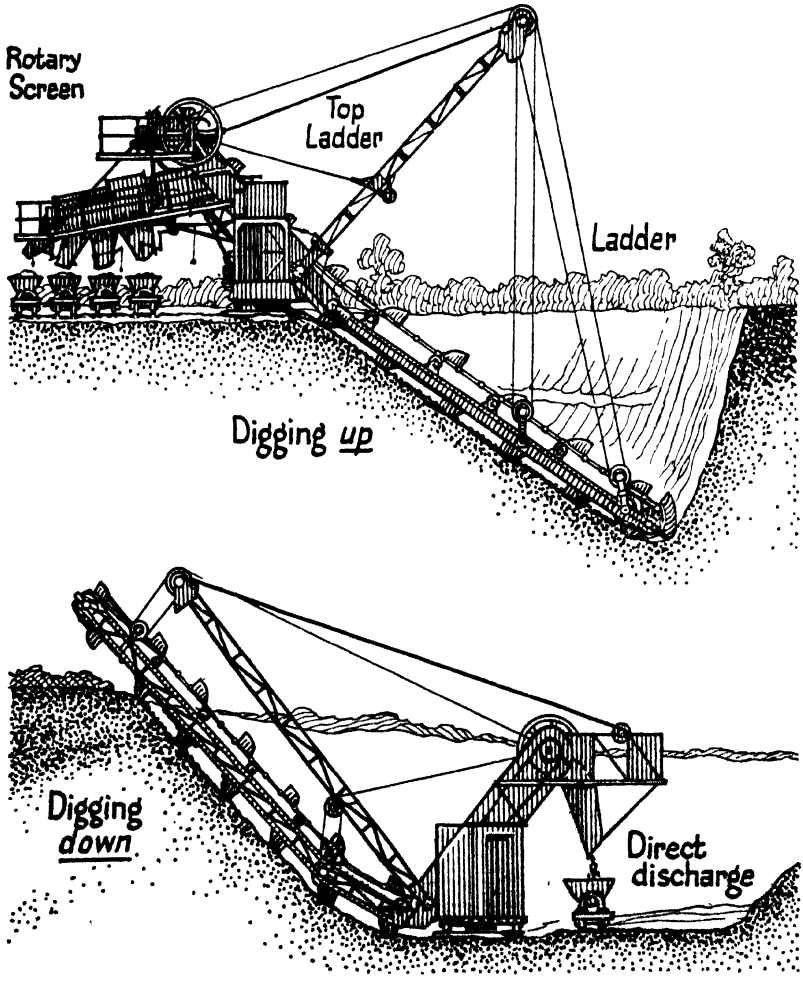
Drag lines are employed on a large variety of tasks. They can open up railway cuttings, to increase the width for additional tracks ; dig deep holes ; cut new river beds for deviations ; clear out old river beds to improve the flow.



Stripping Overburden to expose Mineral Strata is quickly done by the Drag Line Equipment.

Again, they are of enormous value in the stripping out of ore and coal deposits where these are near the surface, as shown in the outline sketch. Big new reservoirs can quickly be opened out ; gravel pits and sand pits worked ; clay can be dug for brickworks, but the list could be added to almost indefinitely.

There is, however, one other extremely useful type, the Multi-Bucket Excavator, or Ladder Dredge, in which a con-



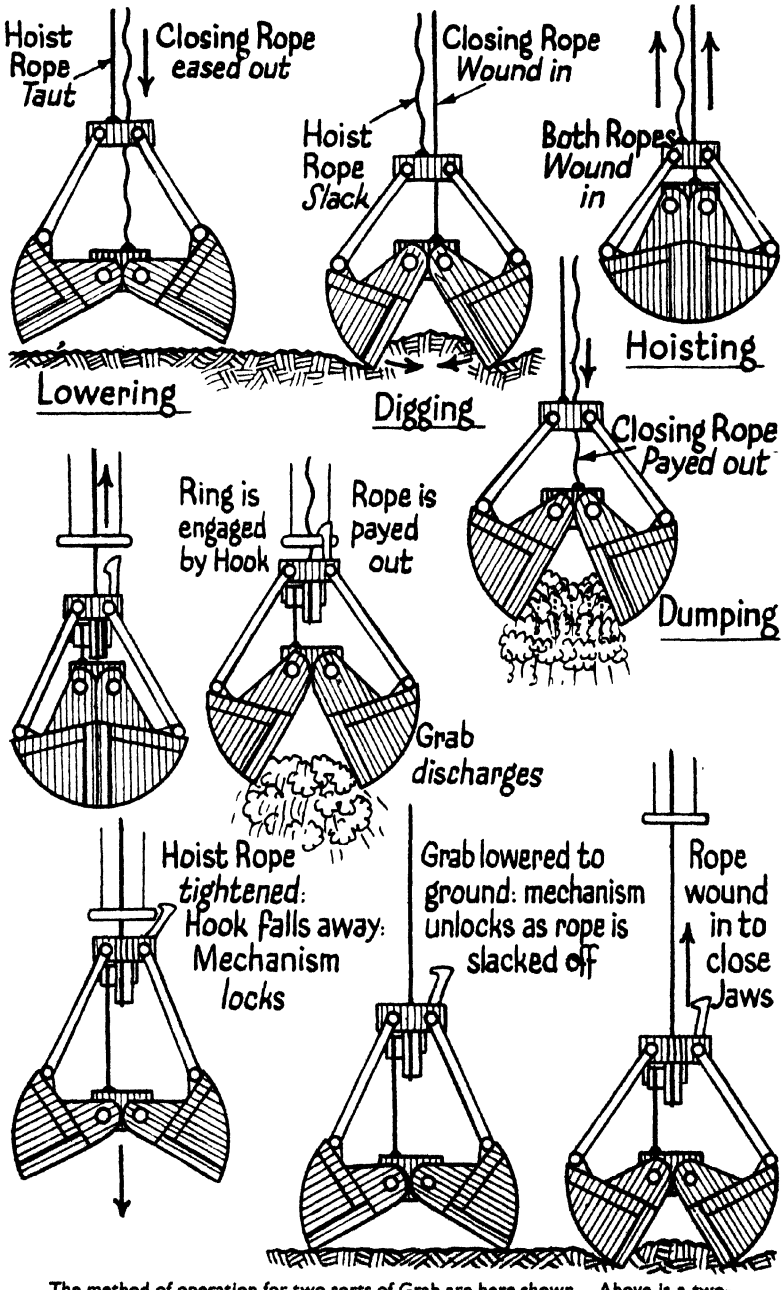
The Multi-Bucket Excavator, or Ladder Dredge, in action.

tinuous chain of scraper buckets is laid on the ground to be dealt with. The chain is set in motion, the buckets pick up their load, and passing up to the top of the machine, are turned over the big sprocket wheels, to tip their spoil into a hopper. Empty, now, they pass along to the end of the ladder, where another set of sprockets turns them over to the scraping action again. The spoil in the hopper may be dealt with as conditions require ; it may be shot into waiting wagons to be removed to the dump, or it may be screened to sort out useful stone. This latter is a very usual arrangement with these machines, often seen in gravel pits, and by means of a rotary screen the gravel can be quickly graded into four or more different sizings. Such an arrangement is shown in the drawing.

The ladder carrying the bucket chain is hinged like a crane jib so that it can be pulled up to a steep angle, or lowered similarly to cut the side of a bank, as in the construction of a artificial waterway or a railway cutting. Clearly such a machine can work either from the top or bottom of the cutting, as may be the more convenient for disposing of the spoil. They are often seen in the claypits of brickworks, and here one of the particular merits of the machine shows to advantage. Nice adjustment of the ladder varies the depth of the cut, and it can be set so that a thin shaving of clay can be taken off ; in this way much work can be saved in the reduction and mixing prior to making up into bricks.

On the other hand, extremely powerful machines of this type are available, able to work in any ground, even where large boulders are found. They will tackle almost anything short of solid stone, and though engines of adequate size are provided, the necessary power to shift 100 cubic yards an hour on a face providing a vertical lift of about 30 feet is less than 28 horse power. They will, of course, work with the ladder under water, making them useful for widening rivers, the standard type of machine being made to run sideways on a stretch of railway track laid at the top of the bank, with parallel tram tracks for soil disposal.

So many variations of these chain bucket excavators can be seen at work that one is tempted to think that no two of them are alike. Wrong, of course, but special conditions demand special machines, and big contracts often justify these. We remember an enormous affair seen at work on the great Shannon



The method of operation for two sorts of Grab are here shown. Above is a two-rope type, below is a single-rope with ring discharge.

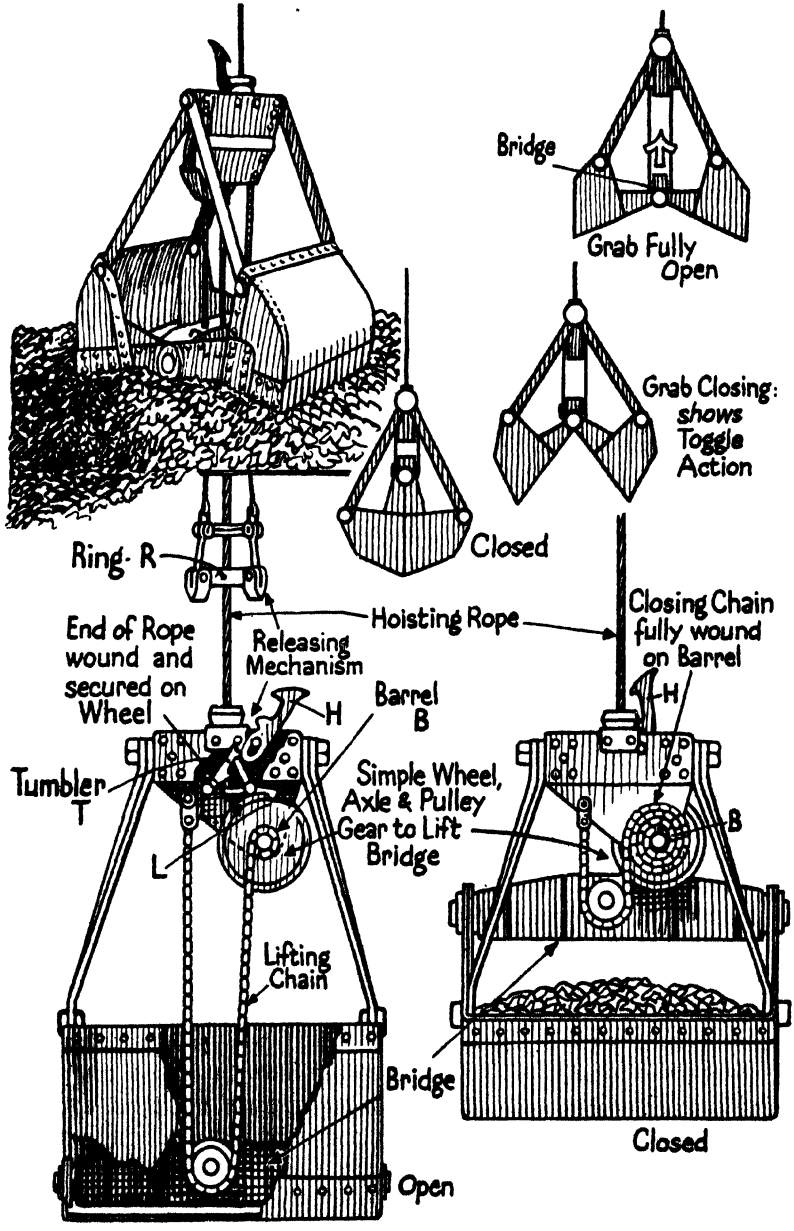
River scheme many years ago in Ireland. This was a German outfit, set to run on a rail track at the bottom of the canal cut to pass the excess flow of the river to the turbines. It excavated, screened and sorted out the stone, crushed it for concrete making, and finally dumped the unwanted stuff to form a protective embankment. This is no particular novelty, but not often can a machine of such size be seen at work in these islands.

We have already mentioned the fact that the excavator can be fixed up as a crane, and the drawing will have shown that this is done by employing the long lattice-steel jib provided for the drag-line equipment. Crane duties have been dealt with elsewhere, but here is another of them, savouring more of the excavator than anything else, often seen in docks, as well as in apparently dry land jobs. This is the Grab.

Grabs are made in scores of different forms, for hundreds of different duties. Some are powerful diggers, others are just what the name implies, grabbers of as much as they can possibly get away with in one handful. Unloading ships is not our line, but some impressive ideas as to what grabs can do can be gathered at a modern dock. But what sort of grab does the contractor employ ?

Generally speaking his use for a grab is in places where excavation must be done under water. Two types are shown in the sketches following. The actual device itself consists of two hinged portions that close together to form a bucket, the closing action being also a digging one, so that a useful load has been enclosed by the time the jaws are closed. For some sorts of soil the jaws may have stout teeth that will interlock as they close. The drawing shows a simple rope and pulley method of closing, but the sequence of actions needs a little consideration. There are at least three ways of controlling the action : the grab can be self-dumping—that is, being lowered so that it touches the ground, the next pull in an upward direction of the crane rope causes the jaws to open ; alternatively, the jaws can be made to swing open by releasing a trip through the pulling on a cord ; a third method being the use of a steel ring hung by separate ropes from the jib head, this releases a trip when the grab is lifted high enough.

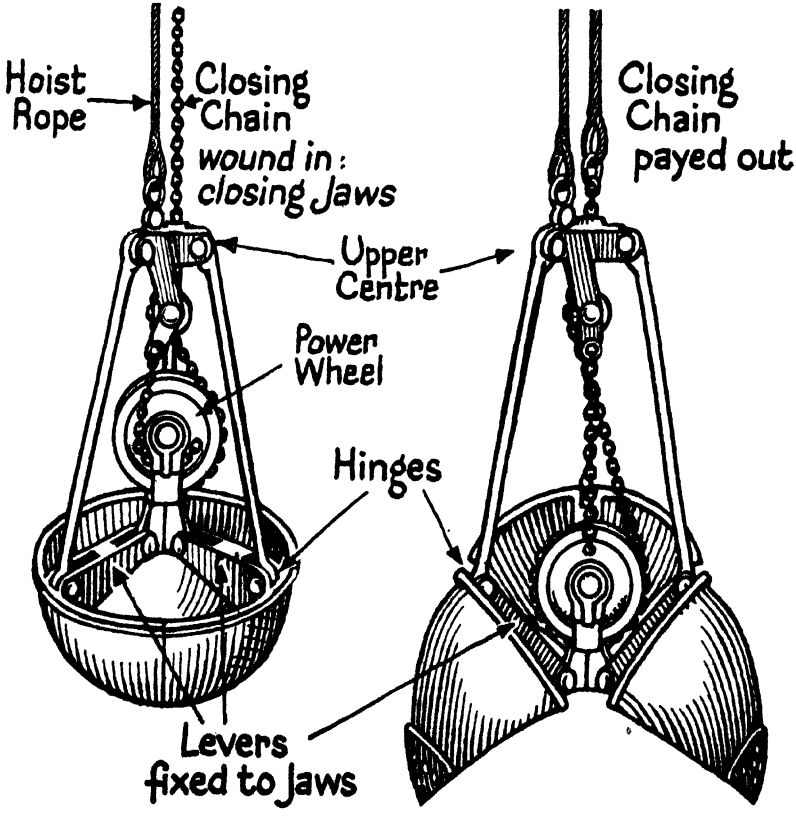
This last method is generally used when a crane is grabbing from a barge for discharge into a storage hopper, or to any-



This Grab has ring discharge gear. The action is explained in the text.

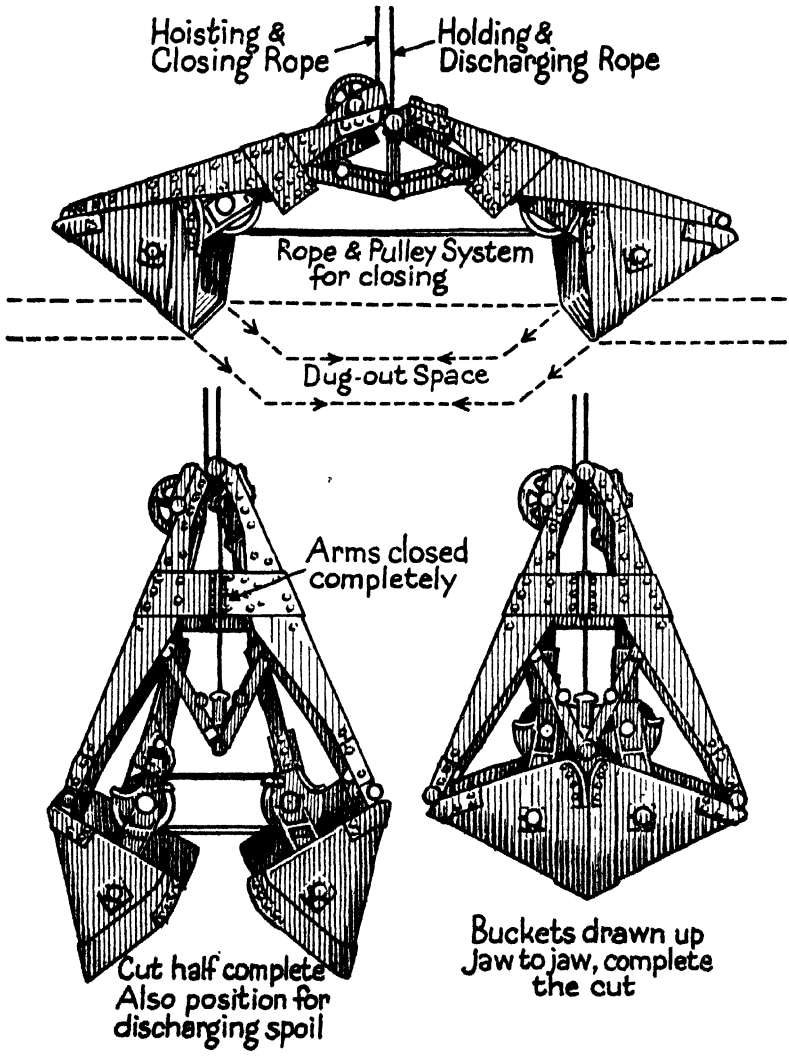
where that the fall of the load for a few feet will not matter. On the other hand, the contractor prefers the self-dumping sort, for that reason in particular. If a load of a yard of muck is dropped from a height into a lorry, it can hardly be a matter of surprise if the lorry springs need immediate replacement. The self-dumping grab does not open until the load is actually in the lorry itself.

The mechanism of a ring discharge grab is seen in the diagram. With full grab, the driver hoists until hook H engages with the ring R and catching on it, transfers the load thereto. Letting out the rope a little, the jaws open through the wheel and axle motion, and the spoil is dumped. To ensure this, the pull on hook H has lifted the tumblers T, this



The Orange Peel Grab is of great value in confined spaces, as for Well-sinking. This one is of two-rope type.

in its turn permits the outer and heavier end of the lever L to drop into a recess in the side of the rope barrel B, as soon as the jaws are right open. The hoisting rope being wound in a little, the hook H falls clear of the ring, but the pressure on the barrel locks the lever L, so the grab remains open and can be



A very powerful dredging tool is the *Level-Cut Grab*. It requires two ropes for its operation.

transferred to the digging operation once more. When it is resting on the ground its weight is off the rope again, the lever L unlocks and the tumbler falls, the barrel is free to turn under the pull of the hoist rope. This unwinds from the barrel, thereby winding up the chain to lift the bridge and close the jaws.

Another clever sort of grab is the so-called orange peel type. These have been made in a large range of sizes from tiny things only 20 inches in diameter, up to huge fellows 6 feet across. They are valuable for dredging out inside tubular wells when sinking piers for bridges. The pointed tines dig into awkward materials like broken stone and rock, gathering in a full load easily. The working is shown in the sketch, control being by means of the ring hung from the jib, and operation in the same way as with the previously mentioned type.

With a good driver and a grab able to handle a cubic yard of spoil—that may weigh 1½ tons or even more—200 yards of what the contractor and his men colloquially call muck can be moved in an 8 hour shift. If the crane is a 3-motor type, permitting quicker operation, then the output may amount to 300 yards.

The level cutting grab shown in the page drawing is a useful contractor's tool, the mechanism is different from those already described, and the arrangement is designed to close the jaws in a truly horizontal line.

Chapter 6

COMPRESSED AIR.

THE number of tasks which the contractor performs by means of compressed air is considerable, in spite of the fact that he must employ a 20 horse-power supply to get five actual horse-power of work at the job. How is it then that he goes on using an apparently wasteful and inefficient method of transmitting power from an engine or an electric motor to a rock drill, locomotive, a hoisting winch or whatever it may be ?

The answer lies in the extreme convenience and safety of compressed air, coupled with the ease with which it can be led long distances—three or four miles if necessary—and yet arrive at the job as fresh and powerful as when it left the compressor, where it was given its energy. Such a state of affairs *can* be achieved, but it certainly demands a well attended pipe line, and one that was well put up in the beginning, as we shall see.

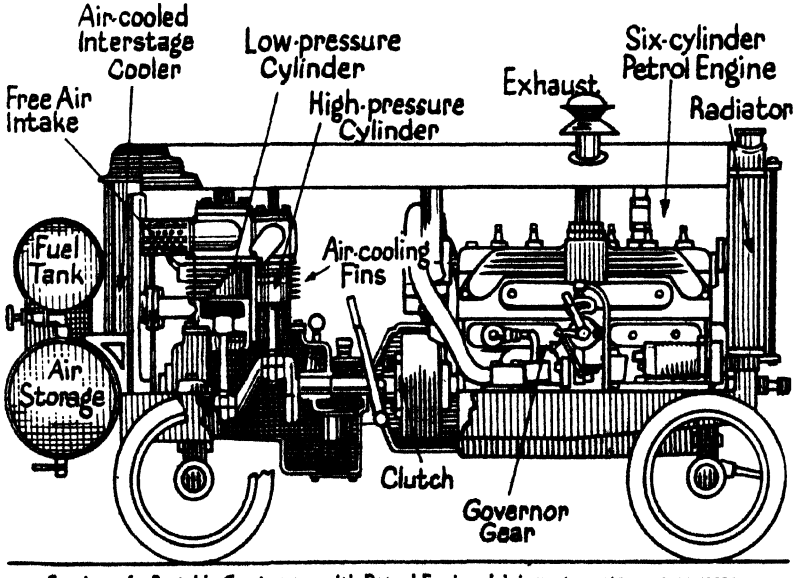
This form of power transmission had its origin in the cutting of the great Alpine tunnels at the end of the last century, and without its aid they would hardly have been completed yet. No doubt electricity could be applied, but the contractor is not much in love with it in the field. Electricity means trailing cables that get trodden on, run over by all sorts of vehicles, and otherwise brutally treated, even though the supply lines can be well slung up on poles. A portable electric tool calls for a length of flexible cable that inevitably gets in the way, and ultimately causes some minor disaster, short circuits and there you are. Wet mud, standing water, and all the usual inconveniences of the working face are the natural enemies of

electric cables, so except for illumination, that form of power remains in the power-house where its convenience and efficiency are unassailed.

This is not a history book, if it were, we could tell some interesting stories of the trials and struggles of those intrepid tunnellers of the last century who gave us the good tools we have to our hand today. Even in our own country now—think of those three-mile tunnels cut to take first canals, and then railways, through the millstone grit of the Pennines. Not much compressed air was available then ! Brute strength with hammer and drill to make holes for blasting charges of black power were all they had in the beginning. One must concede that they also had nerve !

However this may be, we cannot forbear to remember the name of Germano Sommeiller, for his was the invention that made all these things possible. First the rock drill that made progress of 8 feet in 24 hours seem a marvellous affair, and then the development of a convenient portable compressor to supply the quantities of air that the drills required. Their first compressors were hydraulic, then came the reciprocating machines such as we know, driven then by water-wheels.

First let us look at a compressor. A piston fitted with



Section of a *Portable Compressor* with Petrol Engine driving a two-stage compressor

rings to ensure a close fit in its cylinder, runs up and down in its cylinder under the compulsion of a crankshaft driven by some outside source of power. The cylinder head is fitted with two valves, one inlet to allow free air to enter, the other exhaust to permit the compressed air to pass out to the receiver and the air line. These valves may be controlled by springs, or they may not, as we shall see. When the piston descends, it creates a suction effect, and atmospheric pressure—14.7 lbs. per square inch—pushes the inlet valve open. The air rushes in to fill the space created by the descending piston—and it can do this reasonably well even at very high speeds.

The piston now rising, pressure is created to drive the inlet valve back on to its seating, effectively sealing the cylinder against escape of air until the piston has risen nearly to the end of its stroke. By the time the pressure has risen to about 100 lbs. per square inch, as it will do, the exhaust valve will lift and allow another cylinder full of compressed air to pass through. The pressure of air in the receiver acting on the top side of the exhaust valve is the deciding factor ; when this pressure is exceeded by that in the cylinder, the valve gives way, only to shut again when the piston begins to descend once more. The delivery pipe is connected to a large steel tank for storage, from which it is piped to the required place for use. This tank is also useful in that it absorbs the pulsing effect of the " one cylinder full at a time " of a small compressor.

A section of a single cylinder compressor is shown, as well as a drawing of a typical valve. It is usual to provide a spring to check the exhaust valve from lifting until a good pressure has been developed in the cylinder, this may take the form of three coil springs (Simplate) or a specially formed plate as that shown in the drawing.

Compressors are not often limited to single cylinders, nor are they invariably of this reciprocating type. So much will be well-known to those who employ them, of course. Many of the portable compressors so much in evidence wherever the world's work goes on have two or more cylinders, which may be all delivering directly into the receiver with one stage of compression. The non-reciprocating types we will deal with presently.

To make the compressor as efficient as possible, the space left between the top of the piston and the under side of the

cylinder head—clearance space—is kept very small, with the same result that you experience with the pump used to put air into your cycle tyres. The air gets extremely hot, according to a natural law that we need not quote further. All common objects, wood, iron, glass and so on, expand when heated, and all gases obey this rule too, so we expect and find that air will behave in the same way. If we have a cubic foot of air, compressed to a pressure of 100 lbs. per square inch and lead it away through cold pipes to a distant machine it loses that heat the compressor gave it. By the same token that it expands when heated, so does it shrink as it cools, so at the end of our pipe line we have less air than we thought we had.

This loss is due to the contraction through cooling, but it will need little consideration to discover that if the air cools, and so contracts, its pressure goes down as well. Can nothing be done about this ? It could, of course, but not in field operations. So this loss has to be faced, and obviously, prepared for by compressing the air to such a degree that its pressure at the delivery end is what we want. Most tools, such as those of the xcavating type, are designed to employ air at 80 lbs. per square nch.

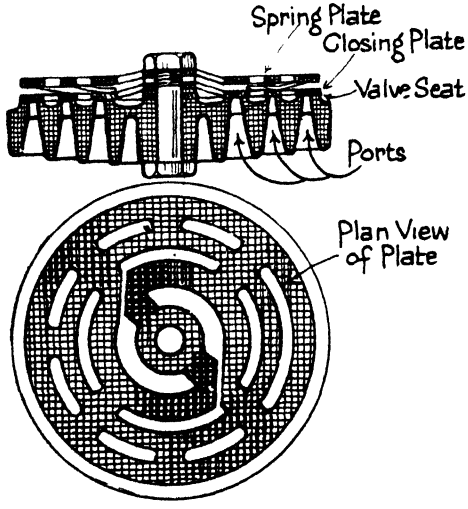
It would be very useful indeed to save some of this wasted energy. Consider the portable compressor that uses up something like 40 gallons of petrol in a normal day's work. In any case only ten of these get to the compressor crankshaft, for it is a good petrol engine that has a mechanical efficiency of 25 per cent. If 60 per cent. of the remaining power gets usefully into the air receiver we shall do well, but a big power-house installation will give us up to 80 per cent. or even more.

A big compressor, driven by electric motor may use up 300 h.p. Now if the contractor can get his power at a halfpenny a unit, his power bill will be around £15 a day. If he can save only 5 per cent., he will pocket an extra £550 over a two year contract. And that is not all, for many contracts use many times this amount in a year. No wonder then that engineers go to so much trouble to get the last ounce of efficiency out of their air compressors.

It has been found that the ideal movement of compressed air through delivery pipes should not exceed 50 feet per second. A thousand cubic feet of free air, compressed to 100 lbs. per square inch, will just get through a 7 inch pipe only 100 feet in

length with a loss of 1/50 lb. pressure. If the pipe is reduced to 3 inches diameter, the pressure loss will be just 1 lb. But these figures and many others like them that the careful contractor's engineer must have if he is to lay out the gear to best advantage can all be obtained from the technical handbooks specialising in them. We quote them merely to show what he may be up against. What likelihood is there of laying down a 7-inch air main to deliver air to a point two, or even three miles away ?

Back, then, to the compressors, and their valves. These are of light steel, rings or slotted discs, sitting on cages or cast iron seatings, as large as possible to permit the free passage of a large quantity of air with a small lift to the valve. To stop as

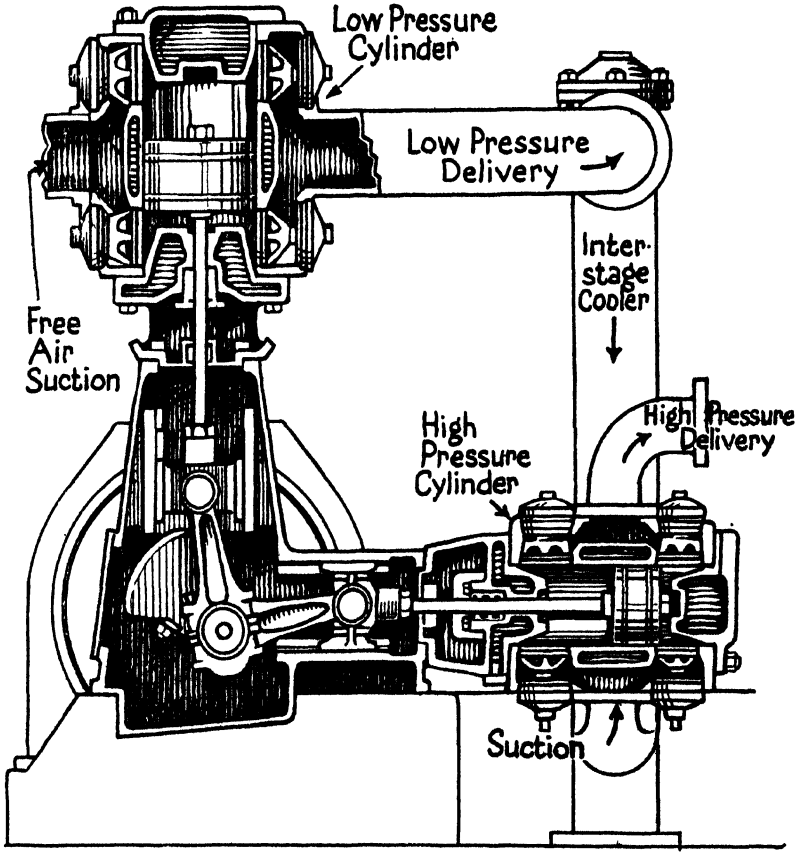


Valve for a Compressor in cross section and plan.

much waste as possible, if the pressure is to be anything over 100 lbs. per square inch, the compressing will be done in two stages, the heat from the first stage being extracted in some sort of radiator, air, or water cooled.

This does not sound too good for a start, but there is one very good reason, and that lies in that heat of compression. This heats up the cylinder, and the metal of that and the piston increase until the oil necessary for lubrication burns away, and a seizure may be imminent. That can be obviated by any

regular device such as water-cooling, or finning for air dissipation of the heat aided by a fan. But the danger lies more in the carrying over of oil vapour in the air, with consequent explosion risks. Soapy water may often be used for lubrication on this account. If nothing were done to keep the temperature down, air at 60° Fahr. compressed to a gauge reading of 100 lbs. per square inch, would have a temperature of about 450° Fahr., this as the result of reducing its volume to one-sixth of its original.



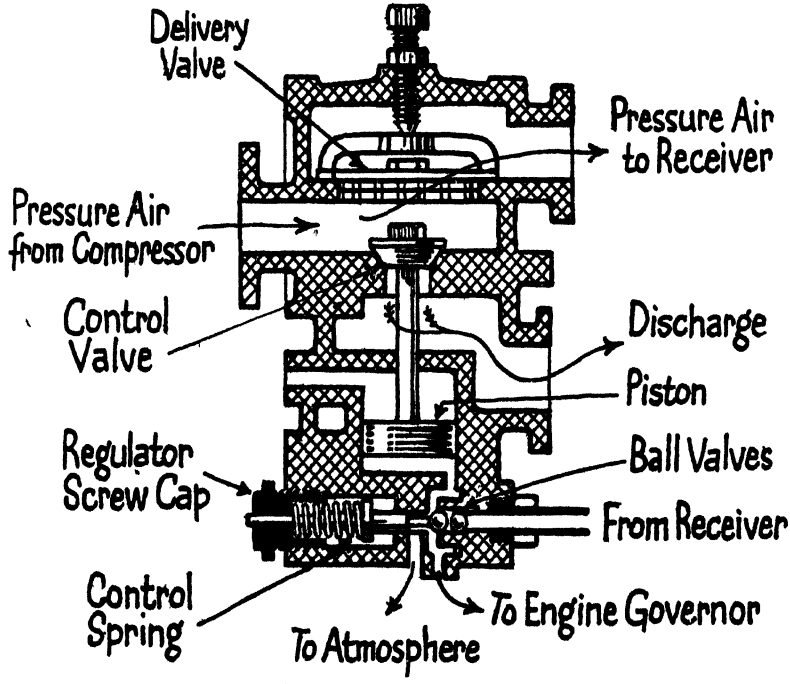
Section of a large Motor-driven two-stage *Air Compressor* for Station use.

When somewhat cooled, the first-stage air will pass to the high-pressure cylinder, where the pressure will be stepped up

to the final degree. If the final gauge reading is to be no more than 100 lbs. then this will most likely be divided into two equal stages. For large quantities of air at higher pressures there may be three or even four stages with an inter-cooler between each stage.

It is calculated that a two-stage machine will save 15 per cent. of the required power for a single stage, but against that must be reckoned some disadvantage in having two cylinders, two pistons, cranks, connecting rods and extra valves. So perhaps the saving would be better stated at 10 per cent.

How much air will have to be provided ? Well, this depends largely on the state of the air lines and the mechanical condition of the tools and machines to be worked at the other end.



Section of an *Unloader* for automatic control of a Compressor Set.

Assuming these to be good, a single road-breaker drill will use up 30 cubic feet of free air a minute. A portable two-stage compressor such as that illustrated will be able to keep two of these going continuously. A larger machine, taking 120 cubic

feet of air a minute, and compressing it to 100 lbs. per square inch, will absorb about 40 h.p. or more in driving. More of this will be discussed later.

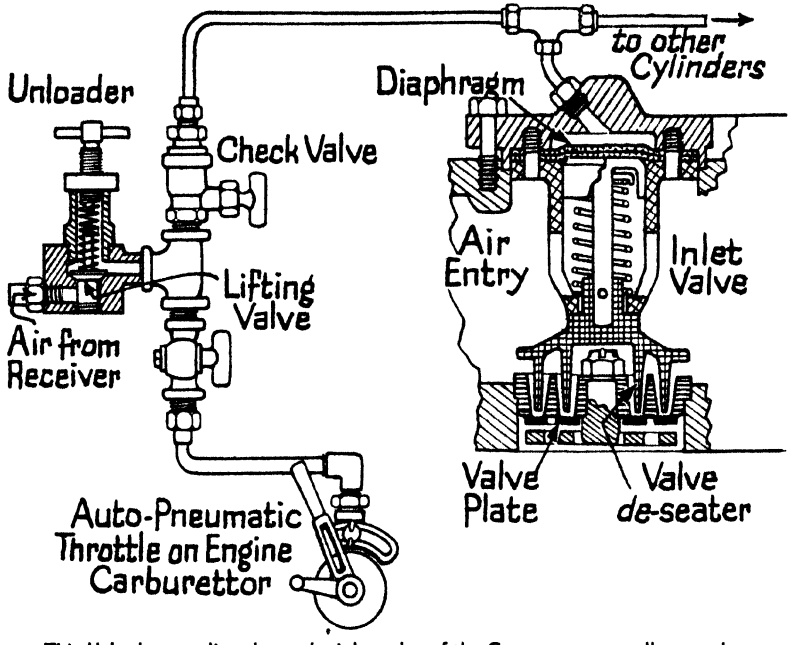
Now it must be quite obvious that men cannot use tools continuously, which means that the compressor will go on making compressed air when it is not required, allowing it to escape through the safety valve on the receiver. To stop this, the device called an Unloader is introduced. Details of two such are shown in the drawings herewith. There is a little complication, but perhaps we can make it clear.

The compressed air passes through the passage and valve at the top of the receiver. A pipe from the receiver goes to a spring-loaded ball valve at the bottom and when the predetermined pressure is reached, say 100 lbs. per square inch, the balls are forced off their seatings to admit air below the big piston. This is lifted, and opens the control valve above, allowing pressure air to escape by way of the discharge opening.

This is all very well, but with a 40-50 h.p. engine banging away under full throttle, this would take the load right off, resulting in the engine racing away and tearing itself to bits. So some of the receiver air that unseats the ball valves passes to a little cylinder with a piston connected to the engine throttle, shutting it down as soon as the unloader comes into action.

When the pressure in the receiver falls below a pressure of about 95 lbs. per square inch, the spring controlling the ball valves re-asserts itself, closing the passage, and opening the underside of the piston to atmosphere. The piston falls, the control valve closes, air is cut off from the governor piston, the engine throttle opens again and the cycle of events re-commences.

The other type of unloader is easier to follow. Receiver air lifts a small valve against its spring and some of this air passes to a diaphragm above the inlet valve of the compressor, opening this and holding it open. Air can still be drawn into the cylinder, but it is blown out again without being compressed. The receiver air also passes to the auto-throttle, shutting down the engine to a slow tick-over, until the pressure falls once again. Those who do not use compressed air, but who find themselves unable to walk straight past a road-breaking gang at work, can observe the action of the unloader at regular intervals.

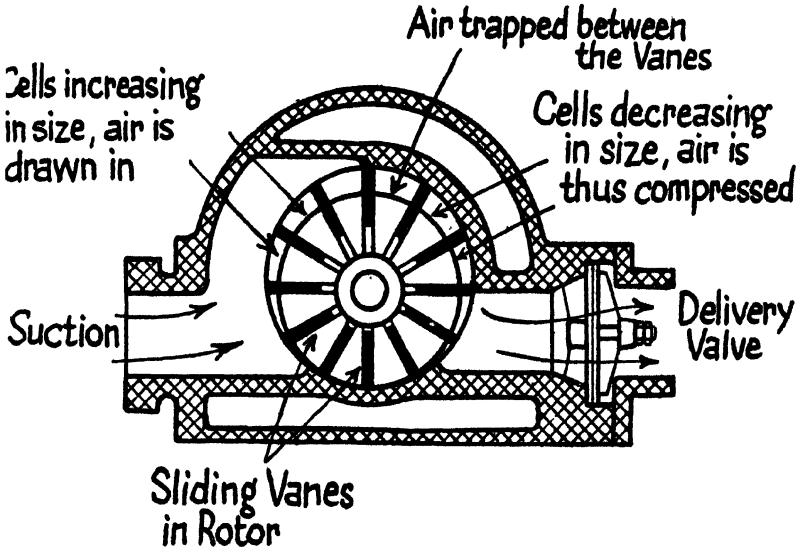


This *Unloader* acts directly on the inlet valve of the Compressor as well as on the engine throttle.

When a number of sets are running together it is difficult to get them all to cut in and out at the same time, with the result that one will do more work than another. To prevent this, one control piston is used to admit air along pipes to each separate control valve. As a result, as soon as the control piston moves and admits air to the pipes all the machines unload at the same time, and cut in again together as soon as the receiver pressure drops again.

Many attempts have been made to design air compressors that will be more efficient, and more free from mechanical troubles than the usual reciprocating type. One well tried type is shown in a section drawing.

In a rotor block of cylindrical form, twelve deep slots are accurately cut, in each of which is fitted a carefully made blade or vane to slide in and out. As the rotor turns, these vanes slide out under centrifugal force, pressing closely against the inside of the outer casing. As the rotor centre is not the same as the casing centre, the vanes move in and out, trapping air

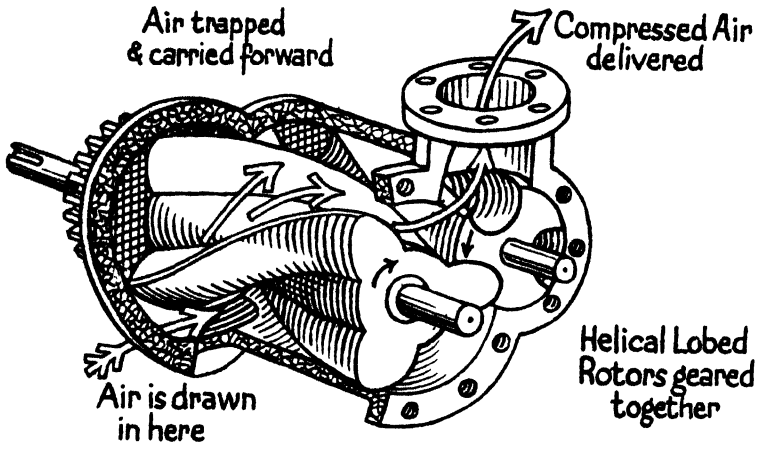


The Vane-Type Air Compressor in section. Observe its similarity to the Vane Motor.

at the inlet opening, driving it round the casing, to push it out through the port on the other side. This port communicates with the receiver.

In large machines of this sort—which run at high speeds—centrifugal force is so great that the friction between the blades and casing is considerable. To check this, rings are set over the blades to restrain them from flying out too far. Naturally the clearances in such a machine have to be very small, measurable in thousandths of an inch, a nightmare idea to the contractor whose machines have to work, not invariably in nice clean powerhouses, but in deep shafts, in tunnels, where dirt, water and misuse are constant conditions. However, with improvements in filters it is possible that such machines will one day replace the others altogether.

A very new type of compressor is also shown here, with the casing partly cut away. It consists of two rotors geared together. The main rotor has three large lobes formed like quick-starting threads, and these engage with hollows cut in the second rotor, exactly similar. Air entering below is trapped by the lobes as they turn round in the close-fitting



An ingenious type of Air Compressor, the *Lysholm Lobe* machine. The two lobes are geared together.

casing, and carried along by the screw-thread action. It is then compressed by the meeting of the opposite rotor and driven out at the upper end. This is a very efficient type of rotary compressor, the work of a Swedish inventor, Lysholm, its principal disadvantage being the necessarily high speed at which it has to be run.

So much, then for the compressor. What of the things it has to do ? A public works contractor who believes in compressed air may have a hundred different devices worked by it. Reference to any catalogue will soon show what those might be, but though there are so many different ones, the principles on which they work are not so numerous.

There are the percussion drills, the rivetting hammers, digging spades, concrete shutter vibrators, in one class. Then we have a variety of workshop labour-savers, drilling and grinding machines, circular and reciprocating saws, all dependent for their action on an ingenious motor. Another type of motor provides power for a very well-known drilling machine as well as a hoisting tackle. Pumps and lifting appliances as well as other ideas, ingenious set-ups of the plant engineer's own devising, can all be seen.

Probably the one that springs to mind first of all is the ubiquitous road-breaking drill, though it is very far from being the original pneumatic tool. It is the legitimate successor of a

line of rivetting hammers, as well as the rock drills we have already mentioned. Consider first one of these drills used everywhere in tunnelling and mining.

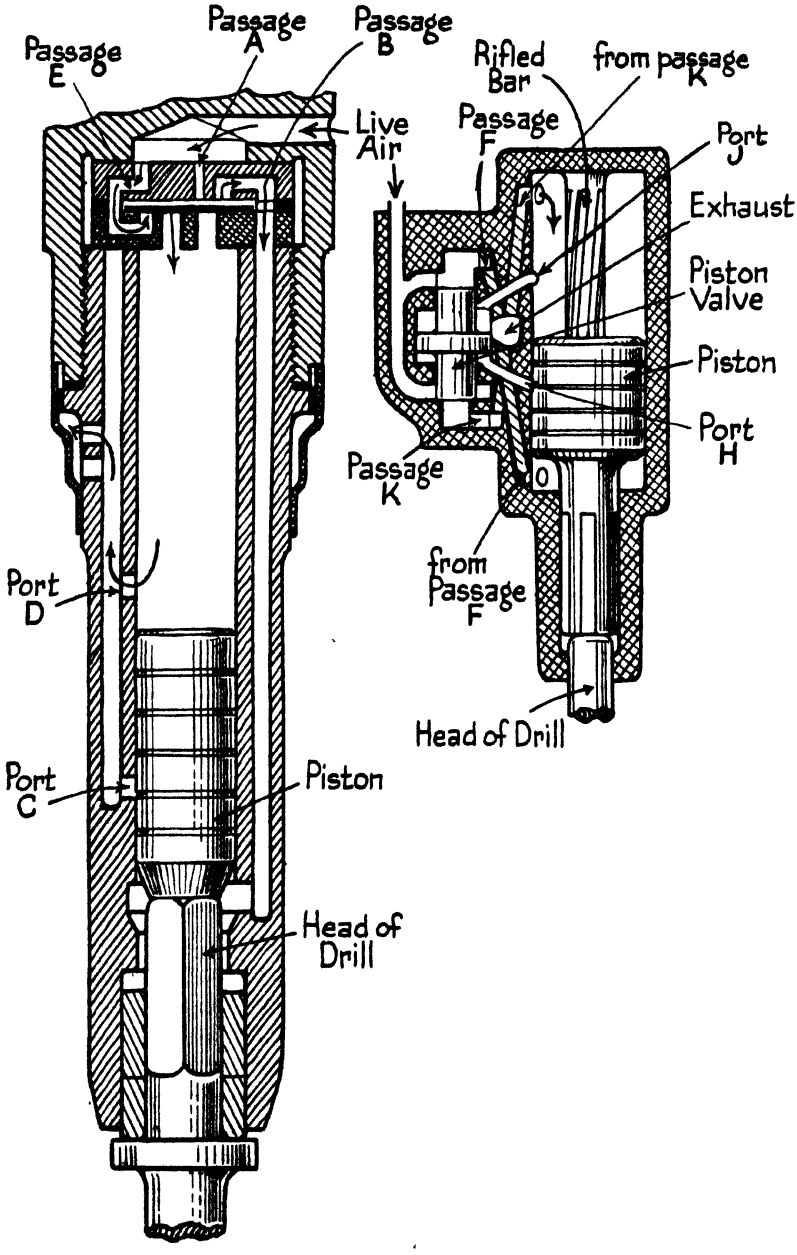
To cut a clean round hole through stone, concrete, or brick demands methods different from those employed in working other materials ; but there is one similarity, that the tool must be rotated at every blow. Each time the chisel or drill is struck it must be given a slight twist, without this, it will jam tight and probably break. The idea of every pneumatic drill is based on this, though it is not used in most of the concrete breakers so often seen in the streets of our cities.

Early designs provided the hammer blow, but left the twisting to be done by means of a spanner applied to the shank of the drill. The invention of the twisting device opened up a large field for air driven drills. They can now be had to cut any rock at almost any speed, within reason, of course, and more important still, to any depth.

There are various arrangements of the mechanism for driving these hammers, they are as simple in their action as it is possible to make them. As a rule, the valve that controls the flow of the air first to one side of the piston and then to the other, is moved by the air itself automatically as the pressure collapses due to the uncovering of an exhaust port. We show three such arrangements, one with a flat plate valve, another with a piston valve, and the third has a spool valve.

Briefly, the hammer has a cylinder inside which a heavy piston runs, and as it is driven down it strikes a blow on the head of the steel drill that projects from the casing. A guide with spirally cut rifling grooves, gives a slight rotation to the piston. Holes are cut in the middle of the cylinder, and these act as exhaust ports when uncovered by the piston. The internal passages through which the air flows are a little complicated in some cases, but we have endeavoured to simplify these as far as possible.

To take the plate-valve type first ; live air—that is how we describe air under pressure—flows in at the top. In the position shown, at starting-up, the piston is down and the plate will have dropped as well, there being nothing to hold it up. So it flows in through the small passage marked A, down through passage B, to the underside of the piston, lifting it up. When the port C is uncovered, the lifting pressure collapses,



On the left is shown a *Plate Valve*, and on the right a *Piston Valve*, operating percussion drills, the latter of older type.

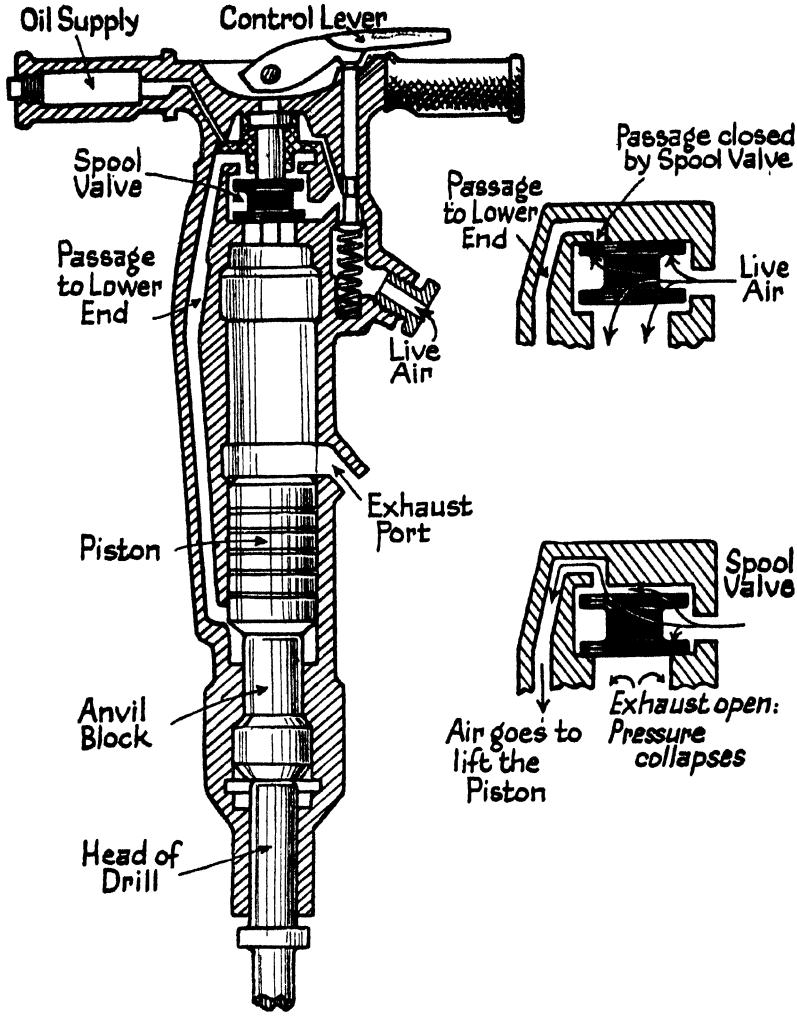
but port D is then covered, and the momentum of the piston sets up a pressure at the top side. This is sufficient to throw the plate valve upwards, and the course of the live air then changes, going by way of passage E to the top of the cylinder, driving the piston down again to strike the blow. When the exhaust port D is uncovered, the pressure collapses, and live air through passage A blows the plate valve down again so we arrive once more at the position from which we started.

The piston valve is a little more complicated, but the ridge round the middle of it is the part that is driven by the live air. In the drawing, the piston has been driven down, and has uncovered the exhaust port J ; and air escaping through the passage catches the ridge in the valve and pushes it into the position shown. This opens the way to the exhaust, but also permits live air to flow into passage F, communicating with the bottom of the cylinder. The piston is driven up, duly uncovering exhaust port H. In the same way as before, the ridge on the valve is caught by the pressure, so the valve is lifted, allowing complete escape of the air that has done its work. At the same time the live air by passage F is cut off, passing now by way of K to the bottom of the piston, driving it down.

This completes the cycle of action, as we are now again where we started. It sounds as if the motion might perhaps be slow, but those who have heard these machines in action will know that this is far from being so, hundreds of blows can be struck every minute. One such drill will be able to absorb about 10 to 12 horse power continuously.

The spool valve type is much the same in its action as the plate valve, the air acts upon the inside of the flanges when lifting or throwing it down ; clearance between the flanges and the casing provides plenty of room for the pressure air to pass to the cylinder ends. Only one exhaust port is cut with this hammer, and that in the middle of the cylinder.

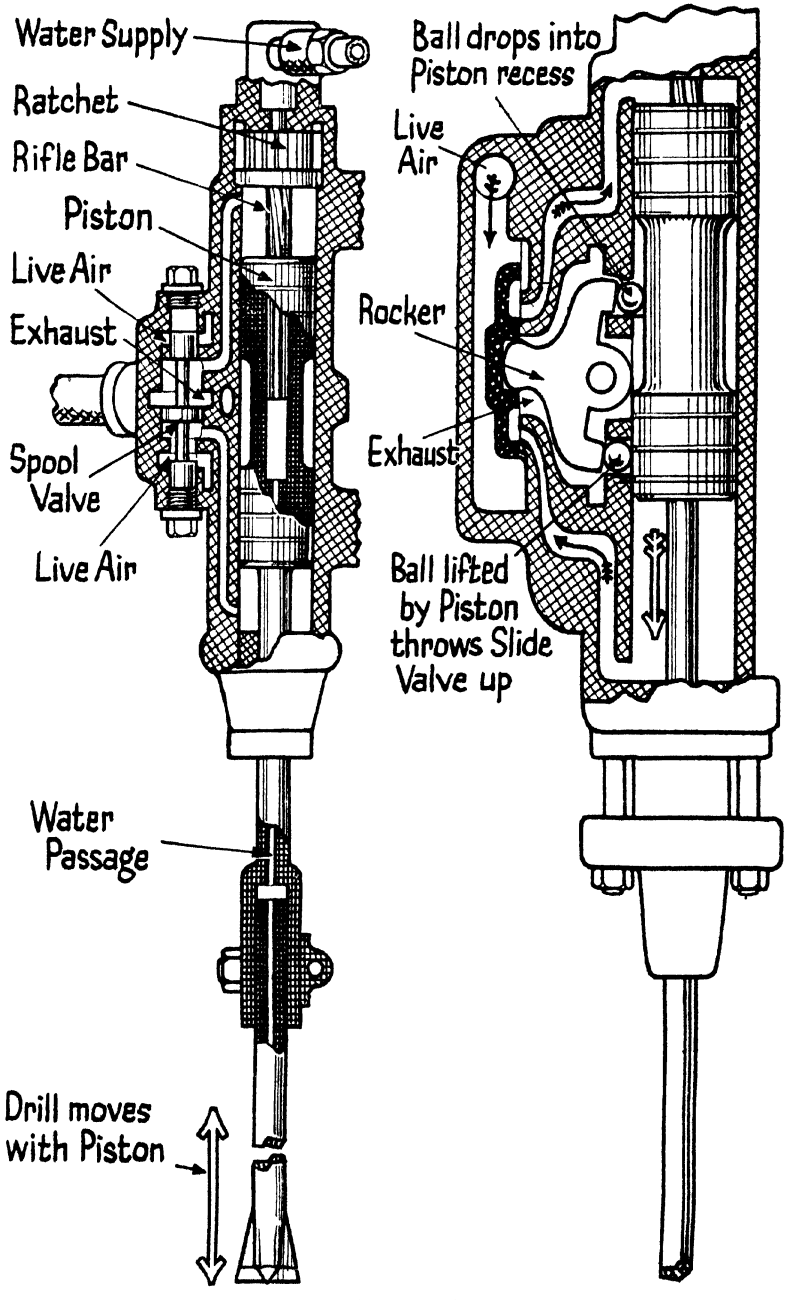
Two big rock drills are shown next. That on the left has a piston valve somewhat similar to the one just described. The valve is moved up or down by the pressure set up on the underside (or topside) of the piston as that is drawn down or up. This being understood, the working of the valve and the consequent distribution of live air and exhaust is simple enough. The slide valve in the other drill is worked automatically by a rocker, operated in its turn by a recess turned in the body of



A Road Breaking Drill in section with Spool Valve operation.

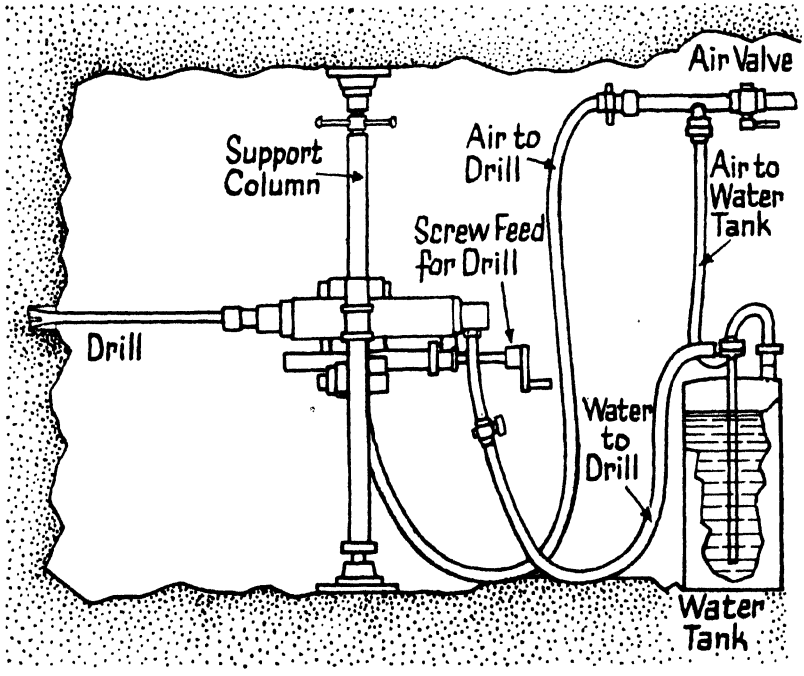
the piston. Here again, this being known, the full action can readily be followed. With these drills the piston carries the steel with it for its full stroke, and a rifled bar imparts rotation to it.

The first one has water circulation to wash out the debris that would soon choke the cutter were it not continuously removed. Air from the mains is passed into the water tank,



Sections of two types of *Rock Drills* for High-Speed Drilling.

a sealed vessel, so that the water is driven into the tubular passage running down the whole length of the drill. The cutting feed is provided by a hand operated screw, seen in action in the sketch. This also shows the method of setting up the machine to its work by means of a screw-extended column, jammed between floor and roof. Some of these columns may be operated by compressed air.

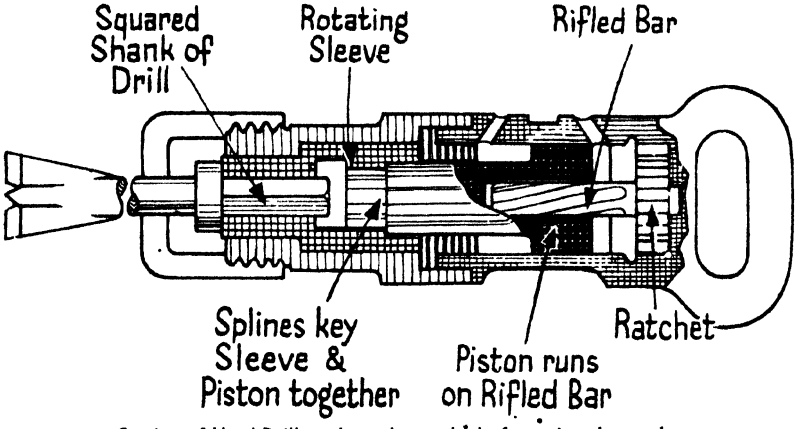


Set up for a *Drifter* with water arrangements for washing out the hole continuously

The method of rotating the drill is shown in a section drawing. The piston slides freely on a rifled bar so that movement either imparts a twist to the piston or to the bar, and this is alternate. The reduced diameter of the piston is splined, to fit a similarly splined part of the cylinder, this is the part marked "rotating sleeve," made to turn round freely but to be gas-tight. The outer end of the rifled bar has a ratchet drum with two pawls to check its rotation in one direction. If the pawls lock the ratchet, then movement of the piston will result in its twisting, carrying the rotating sleeve with it, and in con-

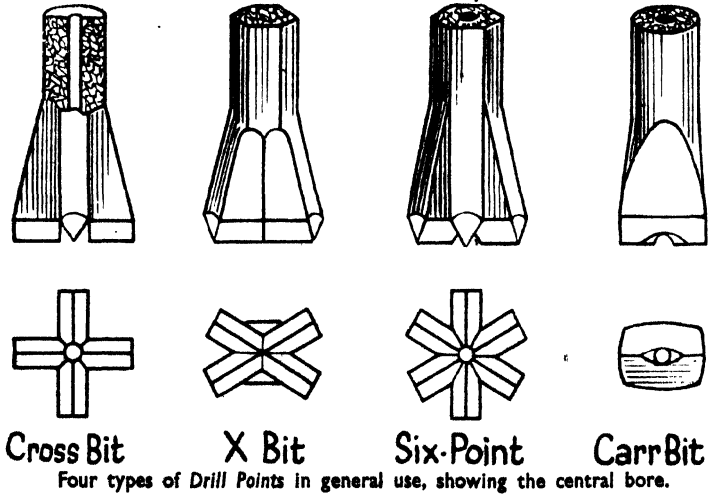
sequence of the squared shank of the drill, the drill also. Opposite movement of the piston results in a turning of the ratchet drum, bringing the rifled bar to a new position.

Where the drilling is to be wet, a tubular passage is drilled right through the rifled bar, the piston and the drill, air pressure as already described blows the water right through.



Section of *Hand Drill* to show the method of rotating the steel.

These machines have to be made with a great deal of care, and just as accurately as modern engineering can contrive. The treatment they receive, and the work they do might suggest that they are only roughly constructed, very far from the truth.

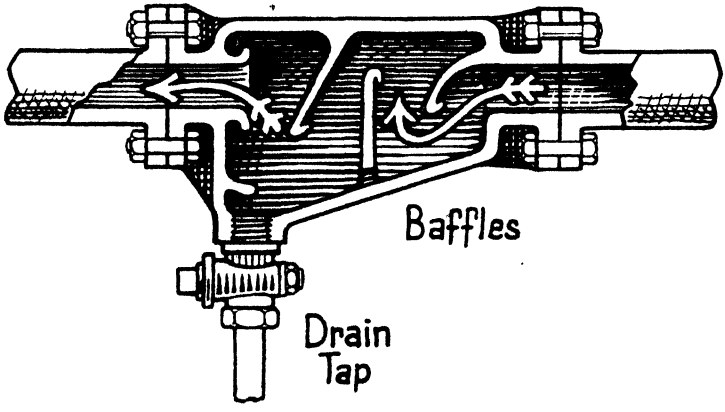


Four types of *Drill Points* in general use, showing the central bore.

Only the finest steels will stand up to the shattering blows, and even so, replacements of working parts must be made at frequent intervals.

The speed at which a tunnel can be driven depends almost entirely on the speed at which the blasting holes can be drilled, and this in turn is entirely a matter of keeping the drill bits sharp. Hand-forging of bits shaped like those shown in the drawing is not easy, particularly as the bits must be symmetrical. On all large jobs an oil-fired furnace will be installed for heating batches of six or eight drills at the time, after which they are put into a forging machine driven by compressed air. Held between correctly shaped dies, the steel is rapidly struck by the air-driven hammer and brought to the proper shape ; after this the central hole is carefully reamed out. In some cases the drill is hot ground to remove any sign of scale, which would prevent the best results accruing from the hardening and tempering processes.

The two greatest enemies of pneumatic tools are, lack of oil, and water in the air. By means of a trap most of the water can be removed before the air gets to the drill, and special oil-



It is important to extract any water there may be in the compressed air. This device (in section) does this.

bottles should be connected in the air line to ensure that all parts are adequately and continuously lubricated. A water trap is illustrated herewith in section.

In addition to these simple precautions, great care has to be taken to chose the right drill for the particular rock being

attacked. In hard rocks a drill striking a good heavy blow is best, but in softer rocks, fast, light blows get away with the job better.

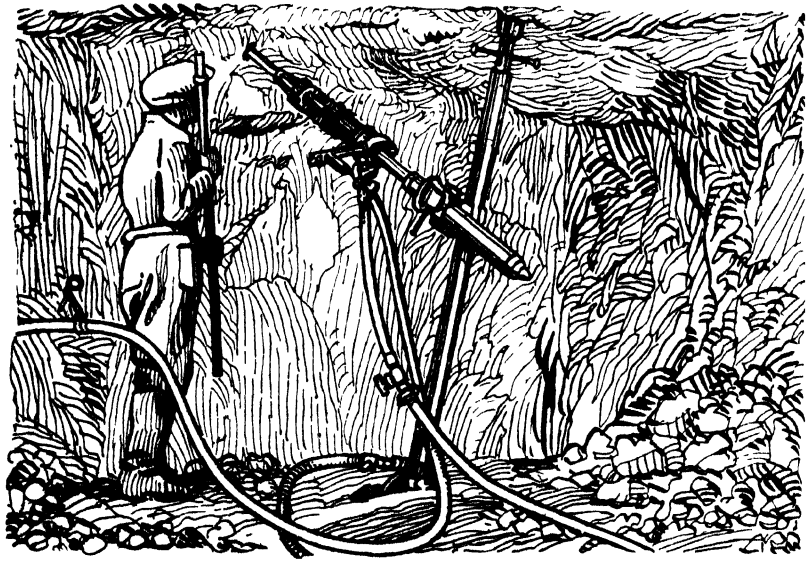
To complete this description of pneumatic working, let us pay a visit to the men at the face. As conditions are likely to be somewhat arduous, we imagine ourselves in sinkers' flannels, heavy boots and a strong leather helmet as a protection against falling rock and low roofs ; so attired we step out along a narrow gauge railway leading into the depths of a small valley. Suddenly we find ourselves beneath the portal or doorway, usually constructed of concrete to prevent any possible slipping of the face into which the miners are burrowing from entombing them completely. Alongside the rails is a narrow ditch, filled with running water which is draining from the tunnel towards some handy runaway point such as a stream. Close to the tunnel wall is the air line, a galvanised pipe about two inches bore. Despite every precaution there will be some leaks at the joints, but a good engineer knows that compressed air is costly stuff, and so he has the line regularly inspected. He realises that a few pinpoint holes can lose enough air to run a small drill, and apart from some loss due to the inevitable friction inside the pipe, these small leaks are all that stand in the way of a full head of air pressure at the drills. One pinhole in a hose connection can lose as much as one horse-power.

High up on the wall of the tunnel is the ventilating line, made in seven foot lengths of a thin sheet metal about a foot in diameter, leading to the suction side of an electric fan set above the tunnel portal. Treading cautiously along the sleepers of the track we hear a dull rumble, which gradually gets louder as an oil-engined miniature locomotive drawing six tubs of broken rock sends us crouching against the tunnel side, to feel the edges of the tubs scraping past our knees. The engineer who knows about these things hopes that the safety pins that prevents them from tipping until required are well and truly home.

At last the tunnel ends and we come to the working face where, dimly lit by electric lamps hung from the tunnel sides, or from pins driven into the rock ceiling, we see the miners. Behind each man stretches a length of rubber hose leading from the air line to the drill. Holding the business end against the rock he presses the control lever, to start the whole thing hammering away like a machine gun. Every now and again he

withdraws the drill from the hole to make sure that it is not jammed, and in an astonishingly short time he has got the hole to the required depth.

Holes having been drilled at the places that will give the best break to the rock, small charges of explosive, such as ammonal, are slid in, each having an electric detonator with two in-



Operating a *Stoper Drill* at the working face of a Rock Tunnel.

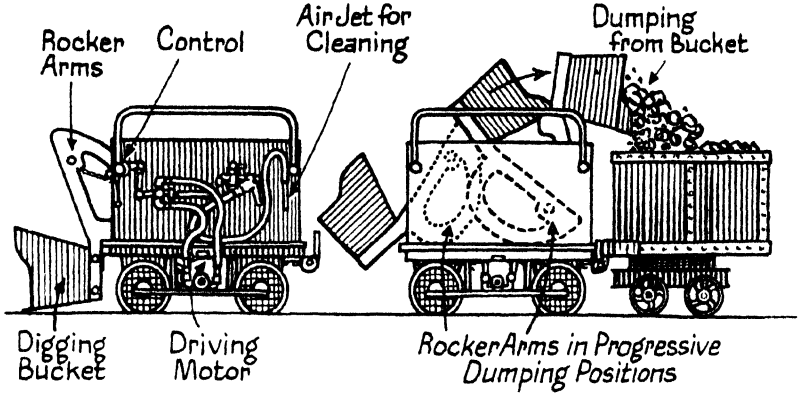
sulated wires leading from the business end to the outside of the hole. The charges are sealed by tamping with well-rammed earth, and then, the wires being connected to a hand-operated shot-firing machine of the magneto type, placed some way down the tunnel towards the entrance. All the miners retire to a safe distance ; the charge hand presses down the handle and a dull rumble announces that they have gained a few more feet of progress.

The machines which drill horizontal holes are usually called Drifters, and those for drilling upwards are Stopers. Such a drill is seen in the drawing on a previous page.

Returning to the working face we are confronted with a great pile-up of debris, loose stone in all sorts of sizes ; these have all to be cleared away as quickly as possible so that drilling can

be re-commenced. Compressed air can be employed at this task also, and the machine is usually referred to as the Slosher, or, in the catalogue descriptions, a Mine Car Loader.

Mounted on flanged wheels so that it can travel on the same narrow gauge track as the wagons that remove the spoil, the main feature of the slosher is a strong steel bucket with a tough shovelling front. This, being forced into the piled-up stone ahead of it, gathers in a load, and then in another motion lifts it up, turning it over into a waiting wagon. The machine is

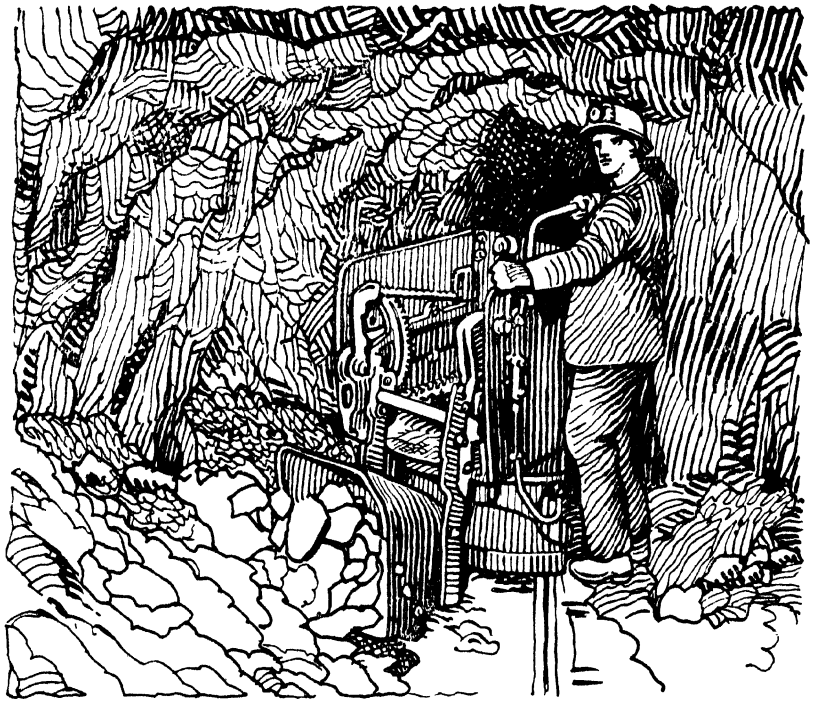


The Mine Car Loader is operated by a Compressed Air Motor.

driven by a two-cylinder reciprocating engine somewhat similar to that illustrated on page 142 ; this engine develops about 15 horse-power, so it uses a good deal of air when in new condition. As it gets the customary treatment that so many contractors' machines are used to, its air consumption tends to rise with age, but in spite of this, its unquestioned usefulness offsets this disadvantage.

In order that it may be able to reach all parts of a wide face, it is made capable of slewing about the centre of the track. This results in some gearing complications, but two men can do as much with one of them as ten men with shovels, and it saves a great deal of weary backaching toil. The device is illustrated in part section and sketch in action.

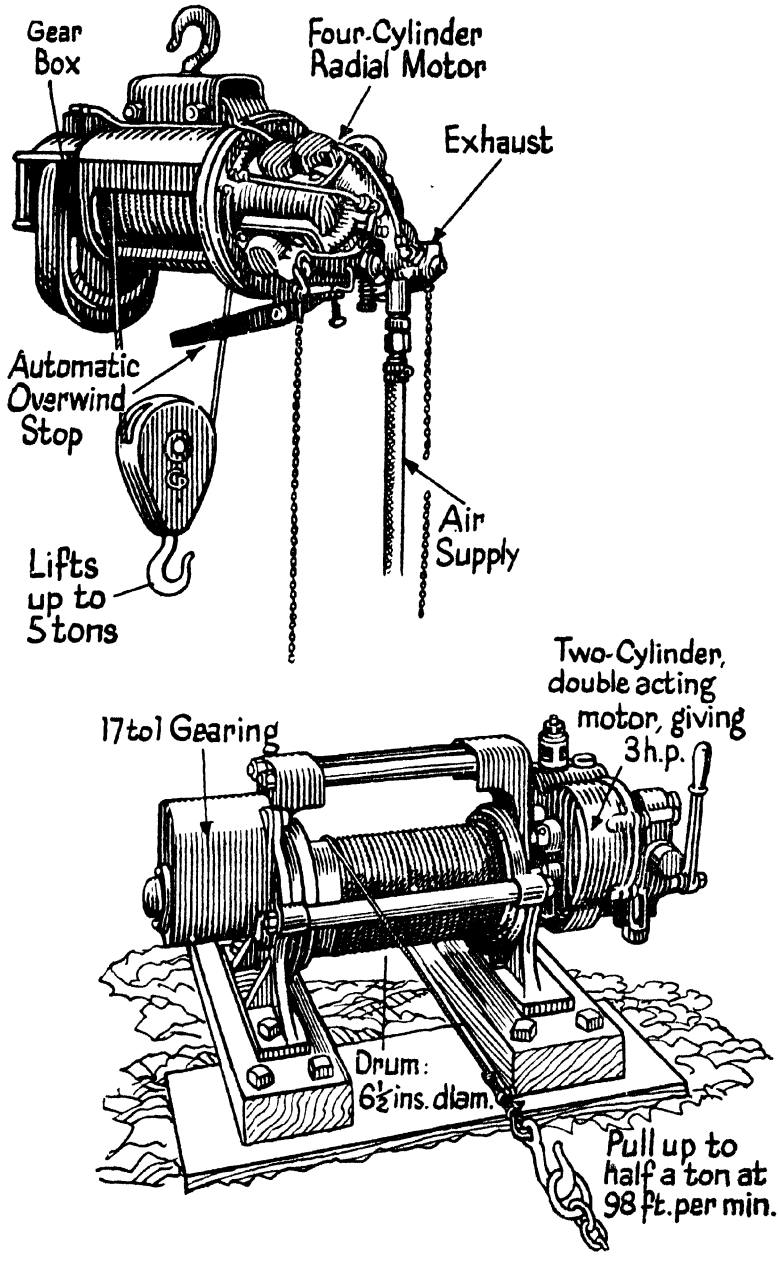
If the tunnel is to be a large one, a smaller pilot bore will be driven first, say seven feet by six. After this the stopers came along to drive sloping passages upwards to the full height of the finished work, the debris being allowed to fall back into the



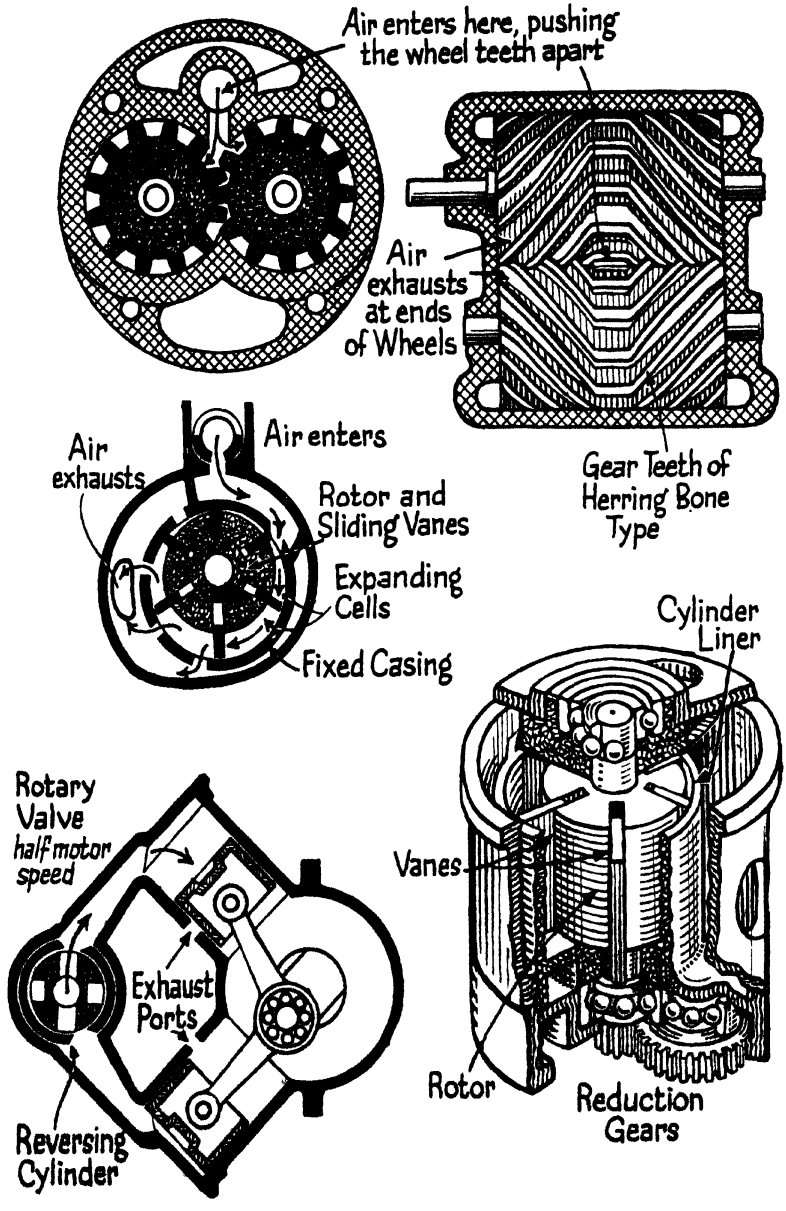
Much heavy labour in confined spaces is saved by the *Mine Car Loader.*

pilot tunnel. At times this stoping is carried up to a second pilot tunnel or heading, which is taken along above the first for some distance before breaking down. To get the wagons along the slope use will be made of winches driven by compressed air and hung from a steel bar driven into the rock, or wedges between the sides of the heading.

These winches may be driven either by miniature engines having two or three cylinders not much more than an inch in diameter, with pistons acting on a common crankshaft turning the shaft that carries the rope drum through reduction gears. In another make the motor is of the herringbone gear sort, illustrated on page 142. This has very accurately cut teeth through which the air is blown, expanding to push the teeth apart, thereby turning the wheels. These turbines run at a very high speed, many thousands of revolutions a minute, and it is this feature that gives them the power that seems so unlikely

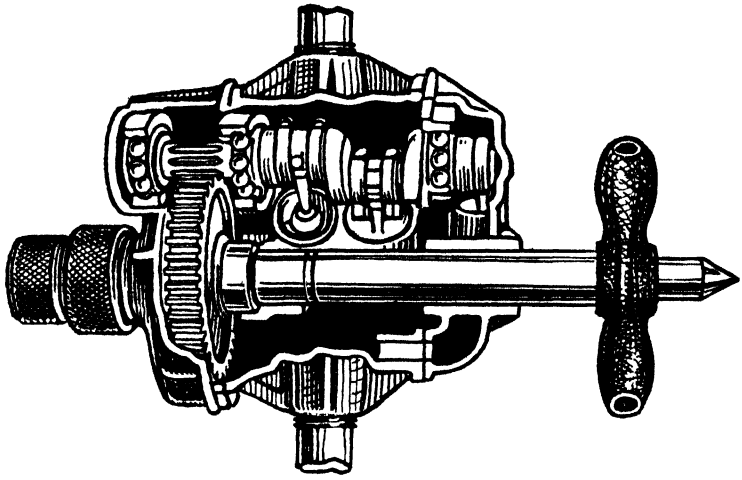


Two arrangements of *Compressed Air Hoisting Tackle*. Both are driven by reciprocating motors.



Details of three types of *Compressed Air Motors* : Top, the Turbine.

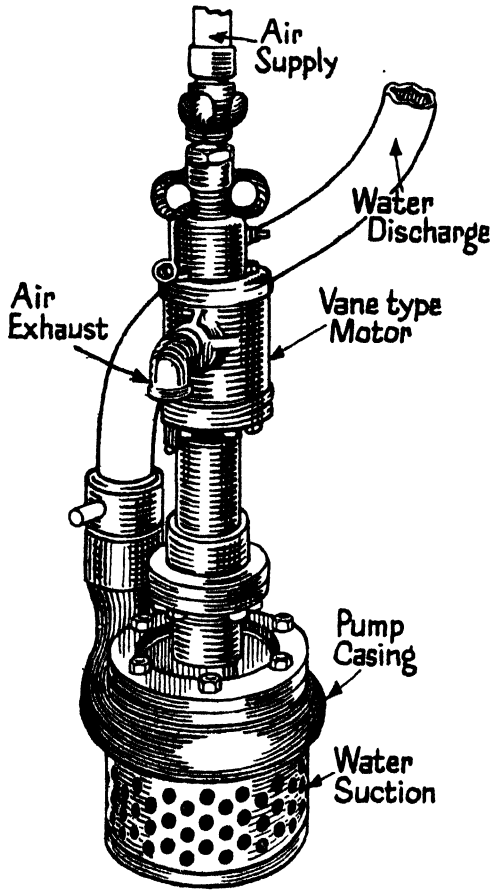
from such a simple arrangement. Winches driven by them will lift a ton with ease. They are much used in coal-cutting machines, and the small number of parts is only one of their advantages.



Exploded view of a Drill with Reciprocating Motor Drive.

Another valuable tool for this work is the cylinder hoist, a simple enough device in which compressed air acts on a piston in a long steel tube—anything from five to ten feet in length, by eight inches in diameter. One end of the cylinder is hung from the roof, whilst the lower end of the piston rod carries a hook for the load chains or ropes. The turn of a valve admits air to the cylinder, and up goes the piston and the load with it ; to release the load another valve is opened gently to lower it as gently as may be desired.

If water is met with in inconvenient quantity, compressed air once again comes into use, being coupled up to drive small centrifugal pumps, which need no suction hose as they are lowered into the water on the end of the air hose. A big discharge hose is connected to the pumps to carry the water away to that ditch we saw outside the tunnel portal. These machines can be completely submerged, and will run continuously under water for hours, the exhaust blowing out in a cloud of bubbles. A vane type motor is most often used, and a governor will be



The Sump Pump is driven by a Vane Motor. It will work completely submerged.

fitted to cut off the air as soon as a set water level is reached, to cut in again when the water has risen once more.

To complete this brief review of the devices that are available to the user of compressed air, we ought to mention the little hand lamps that give a brilliant light from an air-driven turbine dynamo. Then there are tunnel ventilators, jets of ejector type, scientifically adapted to clear away the foul air and fumes after the blasting charges have done their work.

What would the modern tunnelling gangs do today without the unquestionable labour-saving compressed air ?

Chapter 7

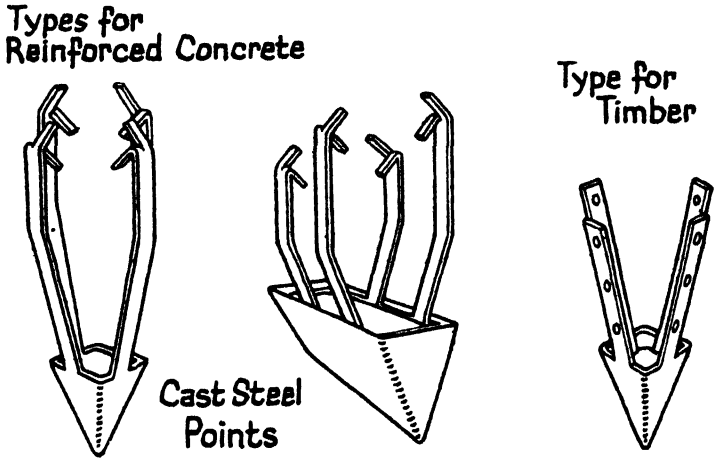
PILES AND PILING.

EVERY building must have foundations of some sort or another, the purpose of which is to spread the load over as much ground as possible. If this ground is hard rock, very little foundation is required, but if it is soft, then the foundations must be extended in some way. At times buildings must be raised on ground so soft that even the largest areas of foundation cannot carry them in safety. In such cases resort is had to the driving of piles to a great depth, relying upon the friction of the soil around them being sufficient to allow them to carry the load.

In ancient times piles were made from suitable lengths of tree trunk, but timber is liable to rot in course of time, though we have some remarkable examples of the material in our museums and elsewhere, being specimens of antique work in this direction. The timber used in the foundations for old Waterloo Bridge, not so old, but old enough to have suffered, having been driven around the year 1815 or so, were found to be in very good order. Many of them were put on to the machines and veneers cut for decorative purposes, some we have seen were used in one or two luxury coaches on the L.M.S. railway, and very pretty they look too.

Nowadays, if we use timber, the logs are carefully squared up and provided with steel points and capped so that they do not " broom " under the blows of the monkey. They will be thoroughly impregnated with creosote to check any tendency to rot.

Modern invention has produced other forms of piles, two of which we will look at with some care here. One of them is for



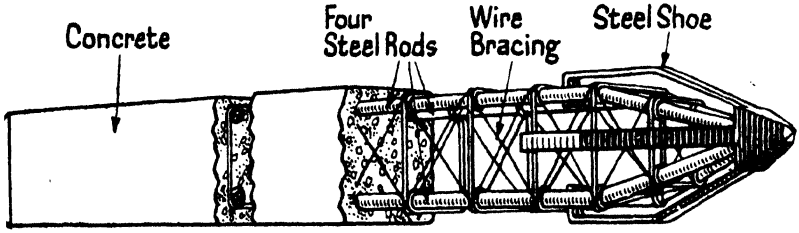
Steel Points for various sorts of piles.

the laying of direct foundations, the other is primarily for a quite different purpose as will be made clear later.

The discovery of the valuable properties of reinforced concrete made possible many new ideas in building work. Concrete by itself will take great loads in compression, but virtually none at all in bending, or tension. On the other hand, steel will take anything in reason in tensile loads, so if steel rods or bars can be embedded and locked in place inside solid columns or beams of concrete, we have a new building material. Using moulds, and pouring liquid concrete into them, having set up the necessary steel framework, a building of any size can be put up in one single piece, in a manner of speaking. What is more, the building can incorporate all sorts of desirable things in the way of cantilevered balconies and galleries that could never be constructed in any other way.

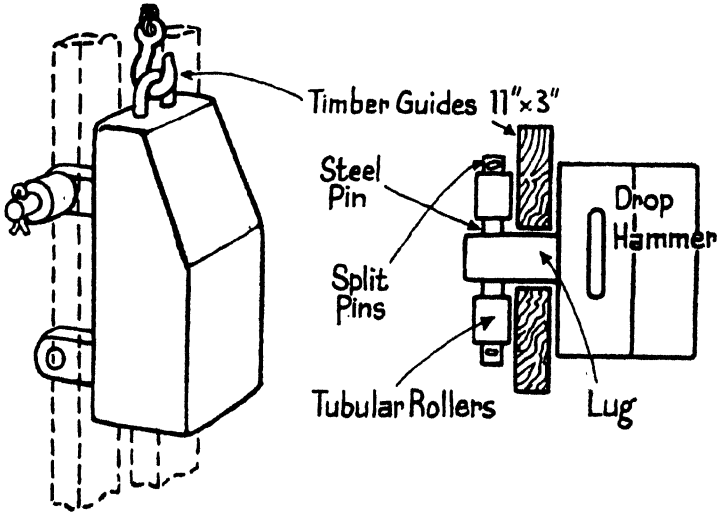
Our concern is with the piling foundations however. Concrete piles are made in a variety of ways, some being cast beforehand and driven in the normal way, others being cast in the actual holes they are to occupy. The first sort are simple enough. They have this advantage over timber, that they can be made right on the spot where they are wanted, so saving much expense in transport, for much of the heavy timber required for piles comes from far-off countries.

The steel reinforcement usually consists of four or more—according to size—rods about one inch in diameter, placed one in each corner of the mould. These are tied together and kept in the correct position relative to each other by wire stirrups placed at intervals of nine inches or so, along what may be a length of anything up to 80 feet. The steel pointed shoe is placed in position and secured, and at intervals, lengths of steel tube are arranged across the thickness of the pile to leave holes through it for convenience in slinging.



A Concrete Pile pre-cast, showing the reinforcing steel rods and point, bound together by wire stirrups.

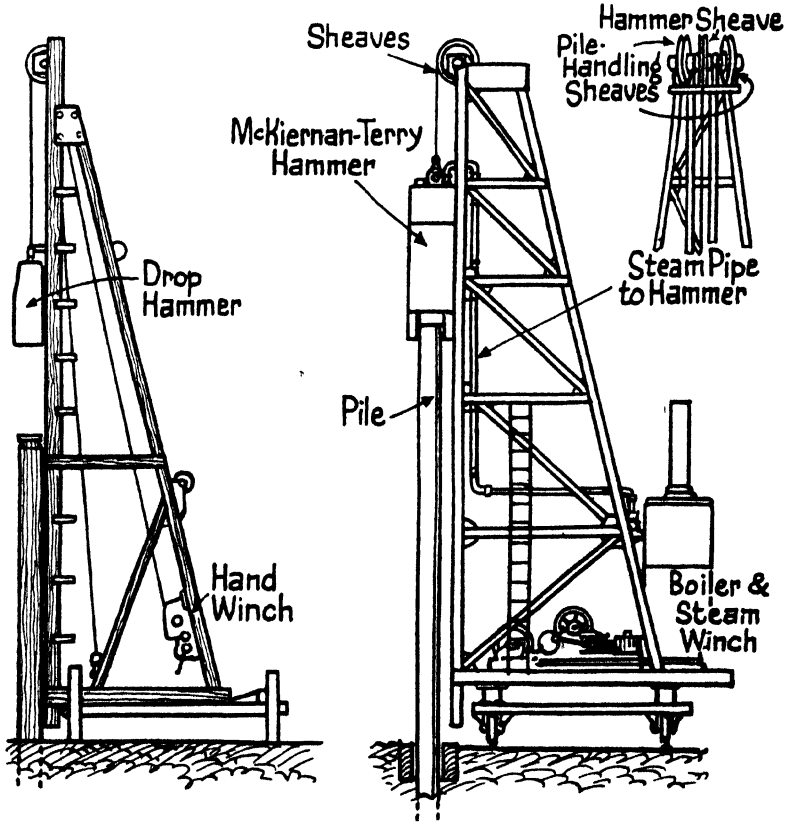
The sketch shows part of the length of an 80 foot pile, which, when finished, may weigh about 7 tons. The concrete is very carefully mixed and rammed thoroughly into the wooden mould that has been built around the reinforcing, this is to ensure a



A Simple Drop Hammer and the method by which it is attached to the leaders.

good filling of all the corners and thorough enclosure of all the rods and wires. It will be wetted each day so that it will not dry off too quickly, and when finished will resemble good quality stone.

The next proposition is to drive it into the ground, a job that can be carried out either with a drop hammer or by one of the various types of steam hammers. Of these latter we have several for review presently.



Details of Piling Frames for Hand and Steam operation.

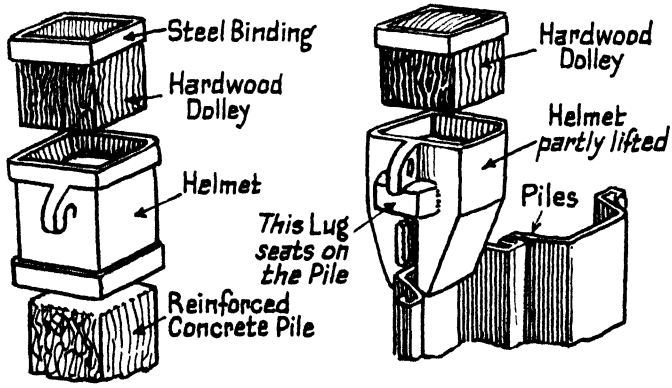
The drop hammer is old-fashioned (the ancient Romans used it) but it still has its uses, and it needs no boiler to provide steam, a great advantage when one realises that it may cost as much as £50 to convey that item of equipment to the job.

The illustration shows a one-ton drop hammer, simply a massive block of cast iron with two lugs protruding from the back. In the next drawing, the hammers can be seen fitted to the leaders, two long timber guides, with pins set through these lugs to keep it snug against these guides.

At the top of the leaders is a sheave, around which a wire rope passes from a winch provided with a quick acting clutch that allows the hammer to be hauled up the leaders, and then being suddenly released, to fall on the top of the pile beneath it.

The driving of the first pile is always a bit of a worry, because the contractor never quite knows what sort of ground he is to work in, whether he is going to get away with the job easily, or he is in for a struggle. Sometimes the piles fairly fall in, each drop of the hammer driving the pile in three inches, on the other hand there are times when, after going down easily for a few feet, the pile strikes stubborn ground and refuses to budge.

To prevent shattering of the pile top, it will be protected by a helmet or " dolley " of cast steel inside which is placed a pad of old rope or sacking, but in bad stuff the pile will break away



Protecting the Heads of Piles to stop damage by the hammer blows.

rather than sink. If there has been any sort of progress at all, the pile will be built up again by placing boards round it to form a mould, which is filled up with fresh concrete. This is allowed to set whilst the other piles are being driven.

At some time or other during the driving of a normal pile it becomes harder and harder to move, which shows that it has reached the condition known as " set." But it sometimes

happens that a clever pile-driver man on the winch can let the hammer fall bang on to the pile, and by use of his clutch, check the blow at the critical moment so that the inspecting engineer thinks the pile is set when it really is not !

This set is the indication as to when the pile will carry the load for which it is designed. To quote an example : A concrete pile 14 inches square is to carry a load of 50 tons with a factor of safety of 2, meaning that it has to resist a blow of 110 tons. The hammer weighs 3 tons and the stroke is 4ft. 6ins., and calculations show that when the pile yields no more than a quarter of an inch at each blow, the set point is attained.

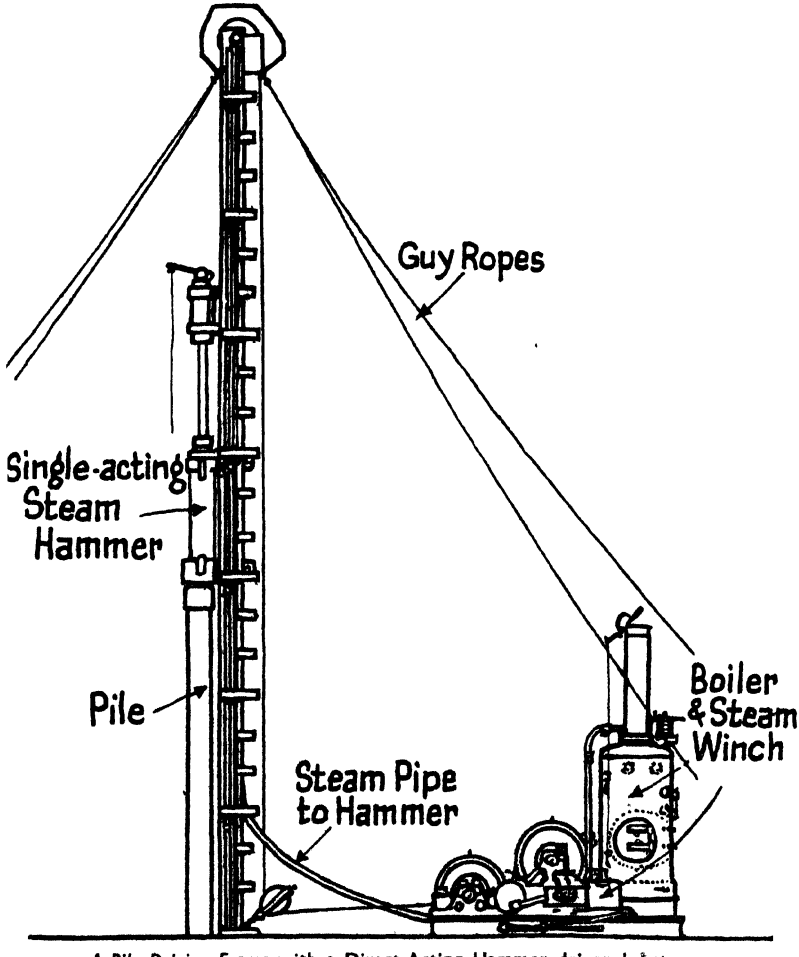
On an important job, where conditions may be expected to be difficult, it is usual to test the geological strata through which the piles must go. This is done by driving a steel tube about 4½ ins. diameter in lengths of 10 feet that can be joined together. Careful regulation of the hammer blows, and exact recording of the response of the pile, enable the observers to draw a graph indicating the resistance at the various depths. Samples of the soil can also be taken.

Driving long piles requires a set of long leaders, for the hammer has to go several feet higher than the length of the pile. As a result, the leaders cannot be a simple pair of timbers, so a pile frame is used which is built of angle and channel steel sections bolted or rivetted together. For convenience in moving the frame from site to site, it will be mounted on wheels to run on specially laid rails, whilst, in order that piles may be driven on the slant as is frequently done in the construction of jetties in fast-running rivers, the frame can be hinged back or raked.

High piling frames may go up to 120 feet, which makes them look somewhat ricketty things, but so long as they are adequately guyed with good ropes, and moved with care, they rarely go over. If they do, then the bits are not much good any more, for the whole thing just folds up, and most of it has to be written off.

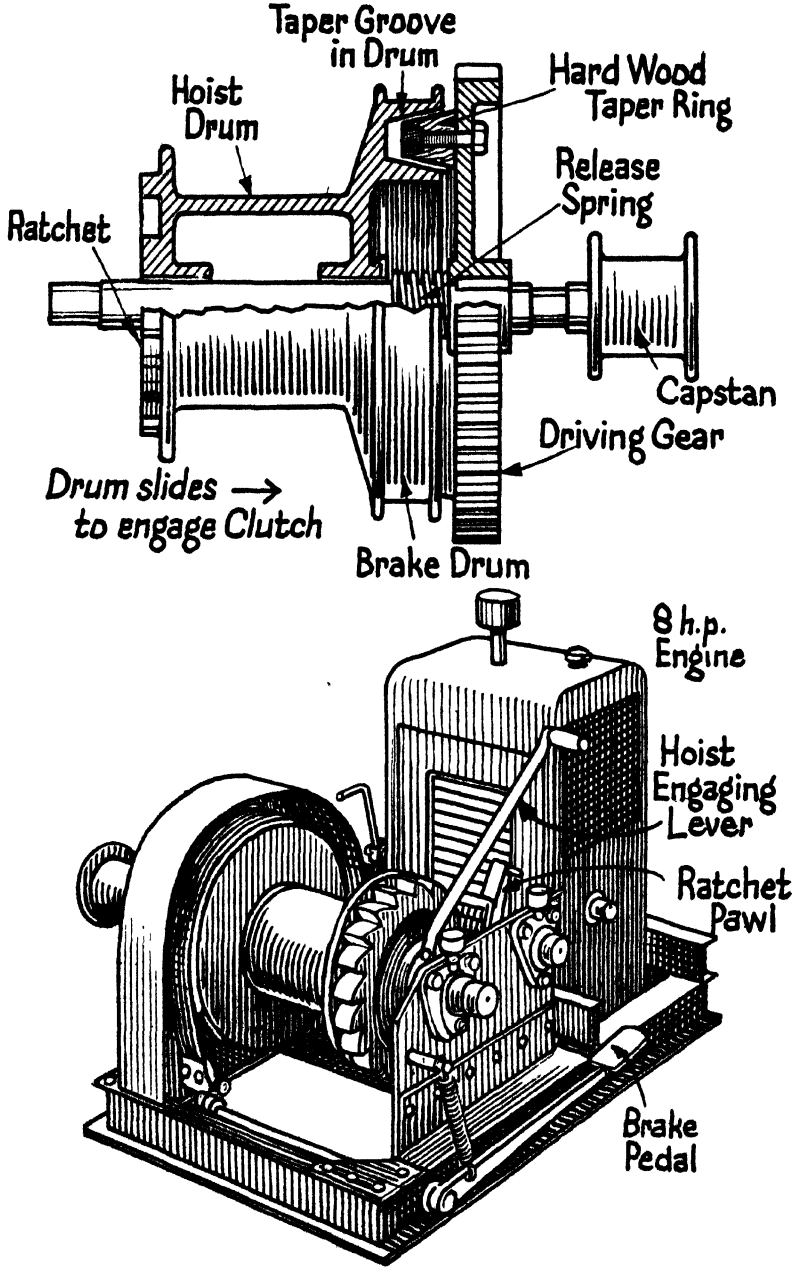
The chief objection to the drop hammer is the relative slowness of the blow. A far better drive can be had by a lighter and more rapid blow, which sets up a vibration in the ground that helps driving. Such blows are struck by the modern types of steam-operated hammers. The first and simpler sort is not fully automatic, each blow being controlled by the operator,

who pulls and releases a long cord attached to the control valve lever. The cylinder forms the weight for striking the blow, and this is lifted by the steam admitted to the top of the piston by way of a hollow piston rod. There is no pressure of steam



A Pile Driving Frame with a Direct-Acting Hammer driven by steam.

behind the falling weight, the energy in the blow being gravitational alone. With the largest sizes the fall is up to 6 feet and the weight of the ram 6 tons. It can strike 45 blows a minute, considerably more than the best that a drop hammer

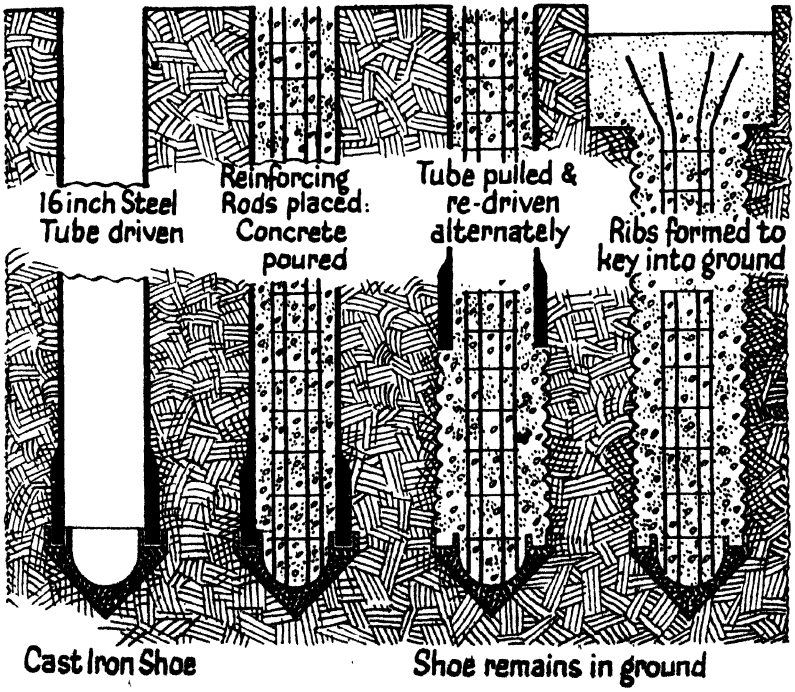


A very good type of Winch for working a Pile Driver, driven by an oil engine.

can do. Observe that the bottom of the piston rests on the head of the pile, so a continuous pressure is kept on it.

For hauling the piles up into position, and lifting the hammer which may weigh up to 6 tons, the piling frame is fitted with a winch driven by steam engine. From this, wire ropes lead over the cat-head pulleys at the top of the frame. A very well-known make of winch with a special type of wood-lined clutch is illustrated, though this example is shown with an 8 horse power oil engine. Where the winch engine is steam-driven, the boiler supplies the steam for the hammer, and this has to be able to evaporate a considerable quantity of water in a short time. It will be of the multi-tube vertical type, with tubes set cross-wise, and in an hour's steaming will use up 1¼ tons of water, producing steam at the hammer at 90 lbs. to the square inch pressure.

We have referred to other types of concrete piles, which may



Forming a Concrete Pile in position by means of a pre-driven Steel Tube.

be noticed here. One of them is illustrated with a progress series showing four stages. A steel tube of the required diameter is first driven to the full depth, being fitted with a loose cast-iron shoe. When down to the proper depth, the steel reinforcement is lowered into position and concrete is poured in. Now the tube has to be withdrawn in short stages —this process will be dealt with presently—and re-driven about half the amount of withdrawal. This rams the concrete out into the hole, forming successive ribs or corrugations that give the pile, when dry, a very tight grip in the ground.

To produce this alternating result, two steel links are fastened to the top of the pile tube, the other ends being secured to the hammer in such a way that the down-stroke rams the concrete while the up-stroke jerks the tube upwards. In this way the tube is withdrawn ready for use in forming another pile.

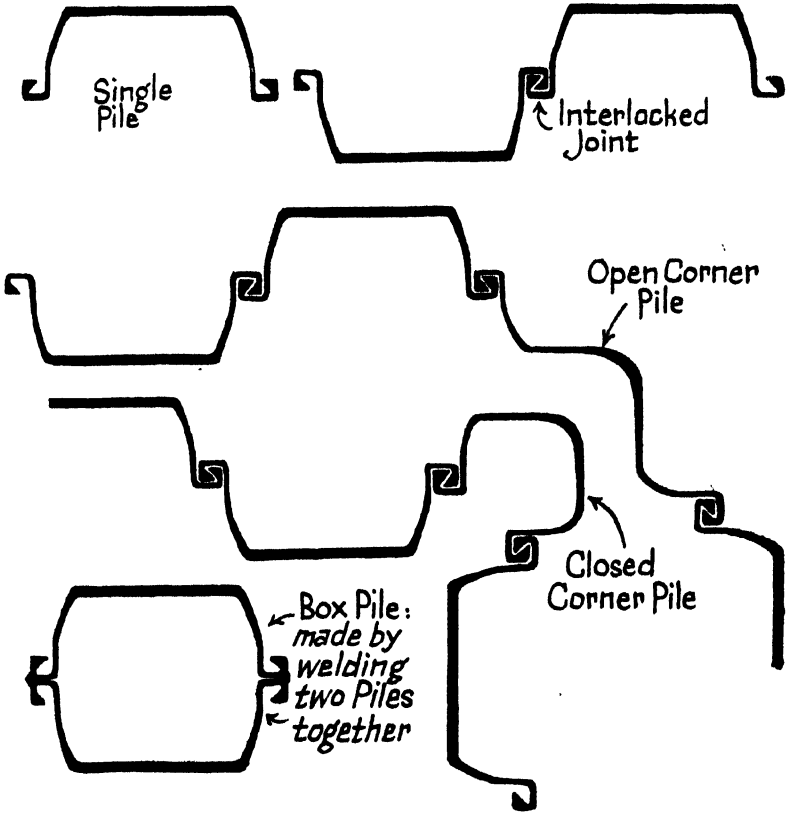
This formation of concrete piles in the ground entirely does away with the risk of shattering the pile in driving, which sometimes happens. There is another method, in which a tube is driven first, and then a steel rod on which concrete rings are loaded is lowered to the bottom, at the same time liquid grout is pumped in under pressure, to form a solid pillar in the hole by the time the tube is out.

So much then for the concrete pile. We must now say something of another type altogether, its main use being in the construction of quay walls, dams and coffer dams, these last being water-tight enclosures of space in rivers where piers for bridges have to be built. The inventor of these sheet piles as they are called was one Larssen, but there are others now associated with the type. The piles are formed in steel about $\frac{3}{8}$ inch thick, with specially shaped edges that interlock with each other, some of the varieties being shown in sketches, which also give an indication of the way they can be arranged to make bends and corners.

One pile being driven, the next one is slid down with its edge interlocking with the first one and driven home, then the next, and so on until all are driven and the job is done. Easy, when it is really like that, but the trouble is that sometimes it is not. The contractor's man frequently discovers this, and his first experiences with sheet piling soon teach him some of the snags, for like all things that look simple, Larssen piling has to be

understood to produce results that are artistic, as they can be to the critical eye.

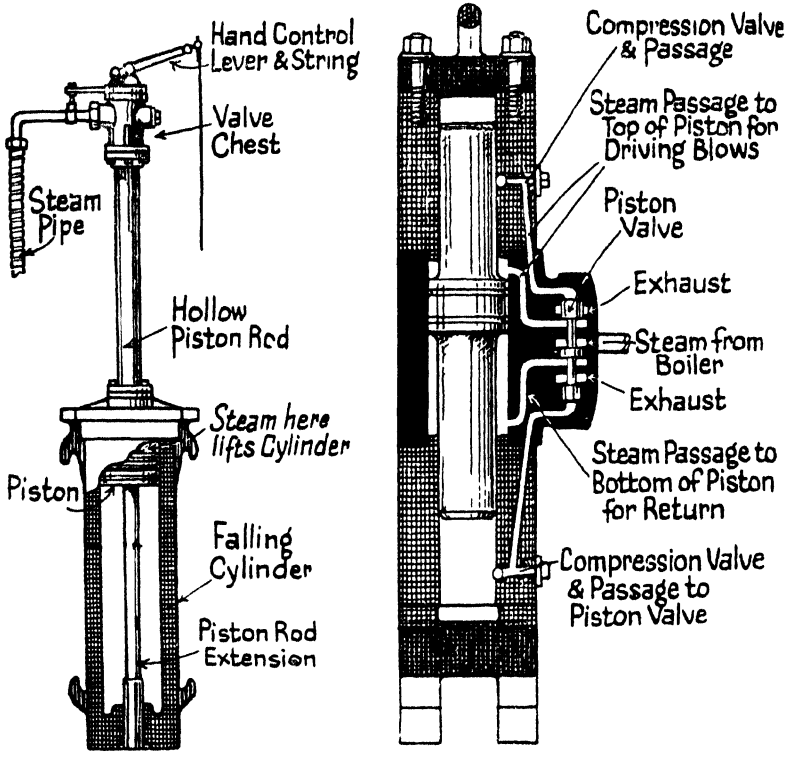
Sheet piling is driven either by drop-hammer or by the automatic steam McKiernan-Terry. A very powerful tool this, easily recognised by the extremely rapid blow that it strikes and



Larssen Sheet Piles are made in various shapes, all interlocking at the joints.

by the absence of any visible falling weight. The vibration set up in the pile keeps it on the move while the hammer is quite automatic so long as steam is turned on. A section is shown in the drawing, but the arrangements are somewhat complicated and need explanation to be fully understood.

In principle this hammer is somewhat similar to the steam-engine piston and cylinder, in which the piston is the hammer.



Left : *A Direct Acting Steam Piling Hammer.* Right : Section of the *McKiernan-Terry Hammer.*

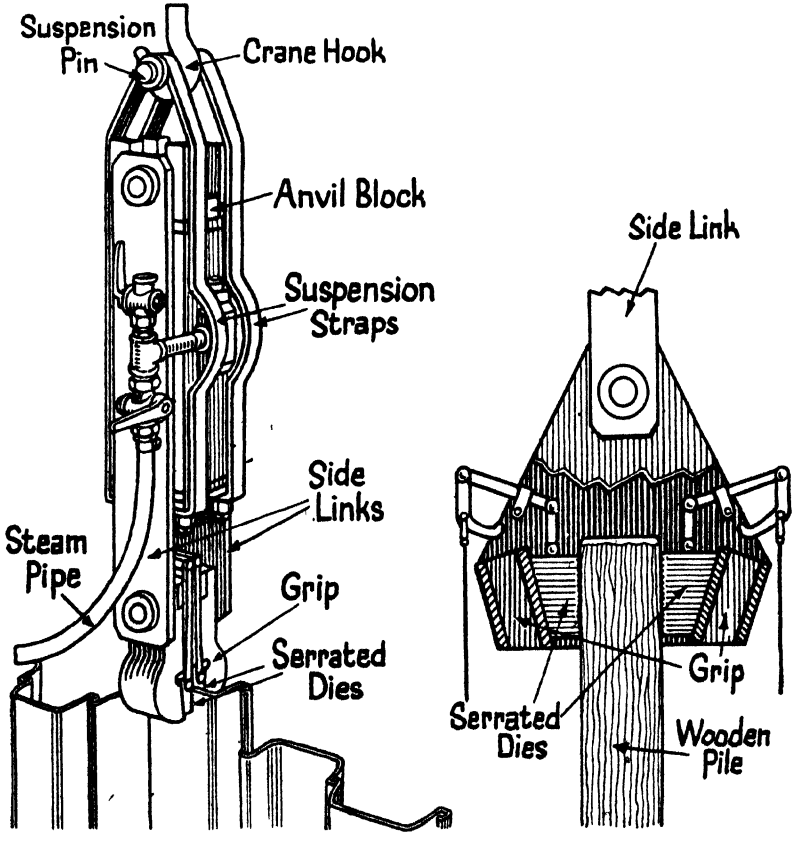
Steam is distributed to either side of the piston for lifting or striking by means of a piston valve, which is always in position to start the hammer working as soon as steam is turned on. Incidentally, compressed air works just as well as steam if convenient, as long as a pressure of about 90 lbs. per sq. in. is available.

The piston valve has three pistons, one at each end and one in the middle, and it controls five steam passages. It depends for its movement on the pressure set up by the piston hammer at either end of its stroke. As illustrated, the piston is at the top of its stroke and the piston valve at the bottom. Steam passes from the centre steam port to the passage opening out to the top of the cylinder, and the hammer is driven down, striking its blow on the anvil block at the bottom. At the same time it sets up a pressure in the closed chamber below, sufficient

to drive the ball-controlled compression valve off its seat and lift the piston valve upwards.

This opens the top of the working cylinder to the exhaust passage and the bottom to steam, so the piston is thrown up and returns to the position from which we started. The compression in the lower chamber is relieved, and that in the upper chamber set up to lift its compression ball-valve. Thus, the piston valve is pushed down, bringing the whole system back to the state seen in the drawing.

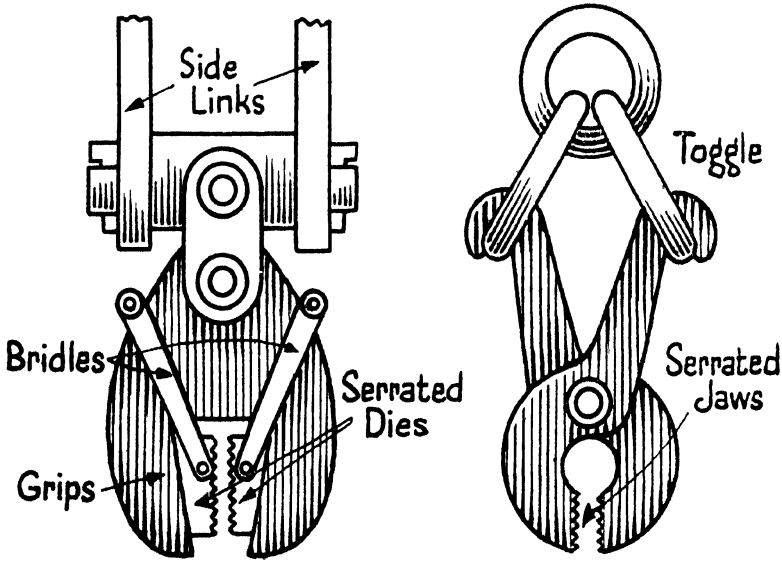
The piston will naturally gravitate to the bottom of its stroke when work is done for the day and this will hold the piston valve in its correct position for re-starting.



Piles are extracted by turning the Hammer upside-down and driving on to an Anvil Block held to the Pile Head by side links and a gripping device.

Hammers of this sort are made in a range of sizes from quite a small affair with a ram weighing no more than 21 lbs. striking 500 blows a minute each equal to 110 ft. lbs., to one with a 5000 lb. ram striking 90 to the minute, each one worth 18,300 ft. lbs.

They can be employed equally well at the necessary job of pulling piles out of the ground, and to do this it is necessary to sling the hammer in a special cradle, upside down, so that it strikes its blows upwards. A powerful wedge grip tool—illustrated here—takes hold of the pile top and once it has got hold it never lets go.

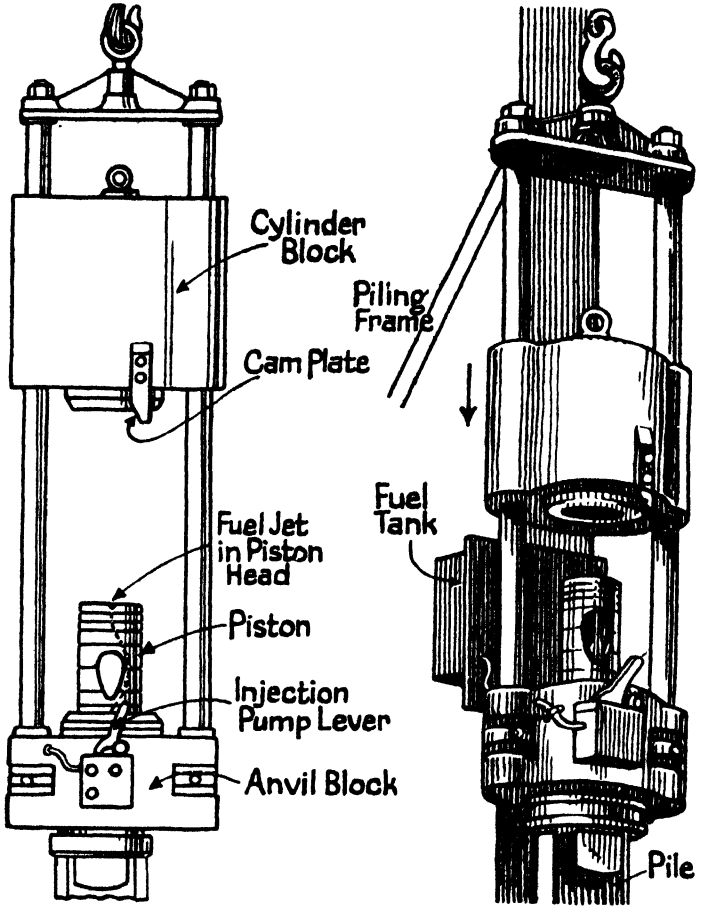


Two devices for gripping Sheet Piles for extraction.

It is useful to know that the McKiernan-Terry hammer will work perfectly well under water, to a depth of 80 feet if necessary. It will need a hose pipe to bring the exhaust steam to the surface, as this could not get away against the pressure of water at any such depth.

Whilst on the subject of these hammers, we should note another type seen in action some time ago, based on the internal combustion engine of compression ignition variety. Sliding on two steel guide rods is a heavy block in which a nicely machined cylinder is formed. Projecting from the anvil block,

at the base of the guide bars is the piston, so placed that it will enter the cylinder nicely. Drilled through its head is a fine bore hole, and this connects with a fuel-oil pump, the lever of which is pushed over by a cam-plate as the cylinder block falls.



Details of an Ingenious *Piling Hammer* working on the principle of a Diesel engine.

What happens in action is this : to start up, the cylinder block is hauled to the top of its travel by tackle, and then allowed to fall. It is, of course, full of air, and this is compressed by the piston to about one-fifteenth of its original volume, sufficient to bring it up to almost red heat. This is

hot enough to ignite the fine spray of fuel oil squirted in the piston head by the action of the pump. The oil fires, and the pressure of the expanding gases drives the cylinder block up the guides, permitting the burnt gases to escape and the cylinder to fill with air again.

The actual blow is, in effect, a double one, being partly due to the falling weight, and also to the reaction from the throwing up of that weight. The jumping height can be varied by altering the amount of fuel injected by the pump, and this obviously mitigates the blow. It must be noted that no physical blow of metal on metal is struck, for there is always a small cushion of highly compressed air in between the cylinder and piston heads, enough to keep the base of the cylinder block away from the anvil block.

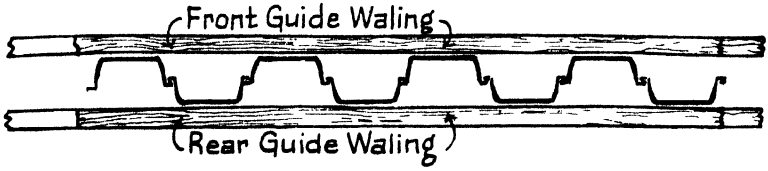
Jumping height ranges between 2ft. 6ins. and 6ft. and the falling block may weigh from 6 cwt. up to 35 cwt. according to size. It is an interesting device, and quite fascinating to watch, though the average pile-driving man will not often think of it that way. So long as it goes on working that is all he will look for ; fascination is for inquiring visitors.

Having looked at most of the available gear, we can try out a small scheme of sheet-piling to construct a dam across a little stream running out to the sea, part of a big scheme to form a large inland lake.

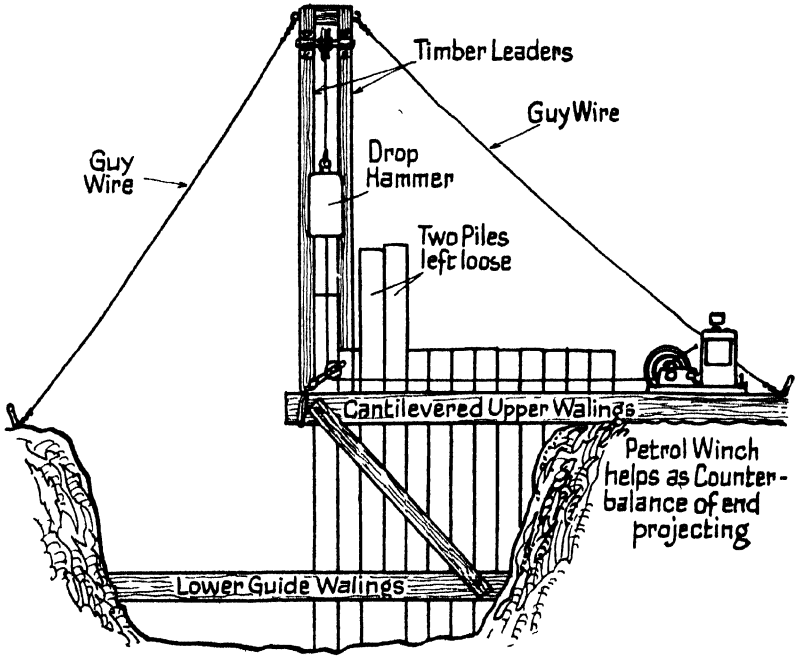
Arriving at the site, the engineer may see a light trickle of water running between deep banks of clay. The uninitiated man will wonder how long it will take to fill the lake from that trickle, and anyway, why not dump a few loads of spoil from what the excavators are digging up half a mile away ? Returning two or three days later, he will perhaps see that high tides, a driving wind, and heavy rain have converted that trickle into a roaring torrent.

No matter, the job is to be done. The first stages are easy. Long timbers, called walings, are placed from bank to bank to form a bridge across the stream. The first trouble occurs when it is discovered that the longest timbers are not long enough. In that case they will be pushed out from one bank on the line of the proposed dam, and their landward ends weighted down with spare piles, sacks of earth and what-not. Our sketch shows the petrol-driven winch and its gear, together with a pair of 30 leaders, all rigged up to hold down the walings. The

leaders are 11 inch by 3 inch deals, and their feet rest upon the back waling, whilst in front is bolted another waling, kept a few inches away from the back one by wooden blocks.



Guiding Sheet Piles into position during driving by means of long timbers called Walings.



Constructing a small Sheet Piling Dam where long timbers are not available.

When the tide is out, bottom walings are set in the bed of the stream in such a way that they are absolutely plumb under the top ones. These walings act as guides for the piles, the first of which can now be hauled up and dropped into the slot between, ready for driving. Being on the river bank, for the first pile

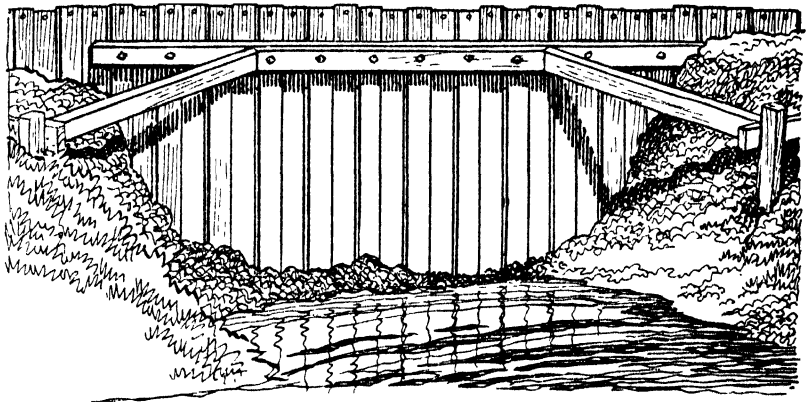
has to be driven well inland to keep the water from getting round it, this pile sticks up higher than the leaders, so the hammer cannot be got up on to the top of it. Well, what do we do now? This does not trouble the expert, who knew it would happen, or at least was pretty sure of it, so he brought a heavy chain sling to the job. The sling hook goes over the pile end, and the hammer is hung to the ring at the other end of the sling. By lifting the hammer a few feet at a time and dropping it, the pile goes in far enough to allow the hammer to be properly pinned into the leader guides, and then the work can go on in good order.

It is considered bad practice to give a hammer drop of more than four feet, but it is a known fact that river beds have a nasty habit of concealing big boulders and such like in their mud, with the sure result that the pile finds them and refuses to budge. So the hammer goes higher and higher until the boulder gives way and probably breaks up. This has the inevitable result that the top of the pile gets badly battered, and to keep the appearance of the job decent, several inches will have to be cut off the top with a gas blowpipe, a necessary proceeding if the piles are to be withdrawn later on.

When six or seven piles have been driven, the timber walings can be pushed ahead, and supported on the piles by bolting. In tidal waters such as the one we are working on, the dam cannot be closed right across, at least two piles must be left undriven in the middle; these act as guides for the next driven ones, but once these are in, the loose ones are lifted to allow the tide to flow through without putting too much load on the timbers. When the last pile has been driven into the far bank, rakers are put on to strut the centre of the dam from the bank. If timber is short, this can be done with wire ropes secured to holdfasts and a good tension put on them with strainers. This is not the best idea, as ropes are risky unless they are in first-class condition, an unusual thing for the sort of ropes used under these circumstances.

With the struts, or ties, as the case may be, in position, the tide-table is studied to select a good low-tide to close the dam by driving the loose piles. Of course there is no time quoted for our particular spot on the coast, so we have to strike some sort of figure from those at the nearest points, which may be 50 miles away. No matter, it will be near enough, or so we

hope. For a few hours the men will have to work like fury with no thought of rest or food, but at last the closure is made in spite of the inevitable boulder that was lying quietly in wait. While the men stow away the gear, the engineer sits him down, watch in hand, to view the water as its level creeps higher and higher towards the tops of the piles. The timbers creak and

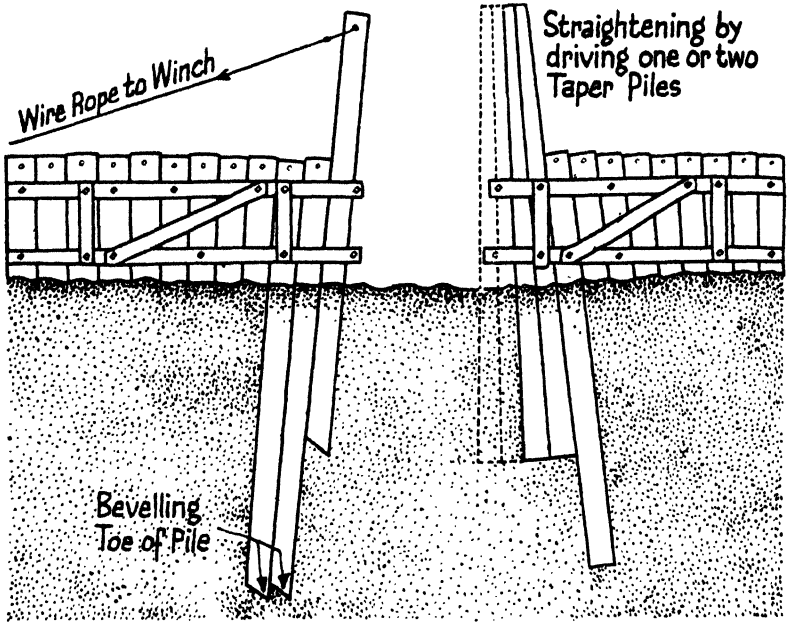


The Dam completed, showing timber strutting.

groan, but they hold. The tide comes higher and higher, a few more inches and it will be over the top, surely the tide-table is wrong—or were we ? If it goes over the top ; or round the banks it will scour away everything behind.

Immediately he sets the men to work again, to build an earth wall continuation of the dam at each end, carrying it back to high ground. At last the rising tide stops, and he can rest assured that all is well except for possible leakage through the piling. To locate these, he throws some loads of fine ashes on the tidal side, these settle slowly down, and are carried into the tiny chinks between the interlocks to seal them effectively.

There was not much real difficulty about the work, for the piles all went in properly, except for the occasional boulder hindrances. What else can happen ? Well, sometimes a pile will jump its interlock out of the next one and will have to be extracted and re-driven, all right if there is an extracting hammer available. Another thing that often happens is when the piles start to run sideways, resulting in an ever-increasing slope away from the plumb. Taper piles can be got to fill the gap and



A bad case of Sheet Piles running out of plumb, and two remedies for the trouble.

straighten up once more ; some men think, however, that to have sloping piles is a mark of the unskilful workman. So they keep a watchful eye, plumbing the piles continually as they go in, checking any leaning tendency by the use of wedges driven against the walings, wood props forced against the edges of the recalcitrant pile, or wire ropes from the top of it to a winch of strainer and holdfast. Alternatively the toe of the pile can be bevelled off to give a lead in the proper direction, but if there are any obstructions likely to be met, this method is not recommended.

When there is any trouble from obstructions and the pile refuses to take it, some men will leave it and put the next one in, hoping that this may be able to hit the obstruction in a more critical spot and break it up quicker. There are scores of tricks in this trade as well as in every other, and a man can only learn them all by working at it.

Sand, especially if it is very wet, can be the most difficult stuff to drive piles into on occasions. The remedy is so simple that it ought to be better known, but sometimes a man

may never be called to work in it until one day it happens as it did to a friend of ours. Beach obstructions had to be put in as counter-invasion precautions, and these took the form of 14ft. lengths of old railway lines.

After battering away for hours, no more than half a dozen had gone in, and those but indifferently, when the idea of water-jetting was suggested. As a trial, a powerful portable pump of centrifugal type was rigged up to throw a strong jet of water out of a half inch pipe. Holding up the rail with one end on the sand, the water jet squirted a hole for it to drop into at once, and pushing the jet down with the rail as it sank they were down and set in a few minutes each.

This method can often be used in regular piling work, but it is not advisable to put them in all the way so, the last foot or two should be driven. Sand will always re-settle, especially if it is tide-washed, but a pile ought to have its feet well anchored in undisturbed soil if possible. We have met this water-jetting trick previously, in sinking well-points.

Hardly to be reckoned alongside regular piling is the driving of wooden sheeting to line trenches, but though it would hardly be an occasion for rigging a pile-driver, it can be a troublesome job at times. We have seen a pneumatic driver designed for it, with a specially formed platform footing for the workman to stand on, balanced on top of the sheeting. Driving is done by a hammer unit similar in action to those found in some of the tools included in our compressed air section, it is in fact, adaptable from such a tool.

Chapter 8

CONCRETE MACHINERY.

CONCRETE can be fairly regarded as a maid-of-all-work where any sort of building is to be done, whether temporary or permanent. It has many other uses, as all know, but we are not so much concerned with its employment as its preparation in the most convenient, accurate and labour-saving manner. Not only its preparation but also its placing and subsequent treatment if it is to fulfil its desired function.

As a building material it has many uses. It can be employed simply as a mass filler to back up stone facings for retaining walls, or for heavy foundation work. This may be regarded as something in the lowest category, calling for a low-grade mixture. Somewhat higher in the scale, but yet calling for enormous quantities, would be the modern form of road construction. Again, it can be used in a fully moulded form for the complete erection of a house, or, in its most advanced development, requiring the highest grade of mixing, it takes on its fullest duty in combination with its co-partner steel to produce the most difficult and intricate works, such as domes, bridges, cantilevered balconies and the like. Finally we have an endless variety of pre-cast utilities, such as might be prominent in the dumps at the beginning of the job, but which will have disappeared altogether by the end of it, having been fully incorporated into the final building works.

Consider, for instance, the modern way of building a railway station, with its platforms built up on a system of pre-formed supports, these virtually disappear under the massive slabs that cover them. These are pre-formed, as will be the cantilevered

roof supports, lamp-standards, and a host of other items. It may be said that railways are great users of concrete in this form, as a journey will demonstrate.

Watching a gang of men mixing concrete, or seeing it pour out of a mixer is apt to give the uninformed observer the idea that anyone could do it. So they could, perhaps, but it would not necessarily be good concrete. Many of the enormous runways laid down for war-time aerodromes have had to be broken up and re-laid because the concrete was bad in the beginning and failed under the load. If experts failed thus to mix good stuff, where would the amateur be ?

Years ago, all concrete was mixed by hand, the men turning over the heap of stones, sand and cement on a wooden platform until they were properly mixed. Then water was added to the preferences of the foreman, and the heap turned over a few more times. Wet concrete was preferred as it was easier to handle.

Cement is manufactured in a highly controlled manner today, and can be regarded as a standardised chemical product that will respond precisely to definite treatment, and that will render a prescribed service when it has been incorporated into concrete. These services are all recorded as the result of rigid testing in engineering laboratories, so the builder can rely on a guaranteed strength in the finished material. So can the engineer who uses these strength values in his calculations for bridges and other such structures. It will be of little avail if the contractor's men are not carrying out the specifications to order, or some other difficulty is in the way of the proper production of the required mixture.

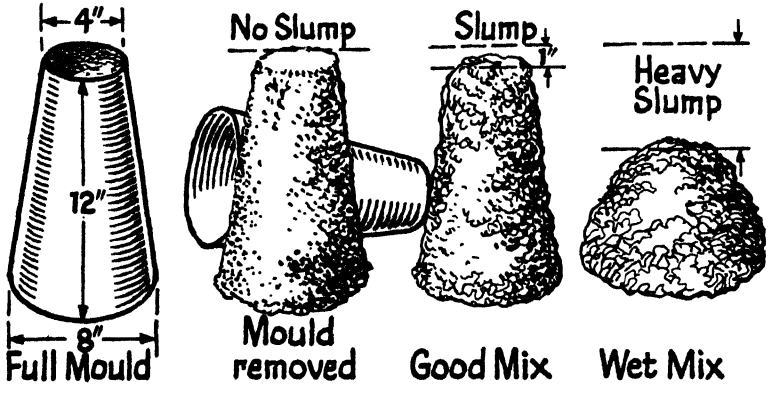
The quantities of the various components in concrete vary to some extent upon the work expected of the finished product, and elaborate specifications are laid down in all the textbooks, and in the information handbooks produced by the Cement and Concrete Association. The idea of concrete is to make an almost perfectly solid mass. Now broken stone occupies only about 40 per cent of the actual bulk of a boxful, sand about 60 per cent. Mix the two together, and we are still short of absolute solidity on account of the air spaces, or " voids," and these are filled up by the cement.

A fair average grade of concrete for a large range of work is usually described as 1 : 2 : 4, that is, of course, 1 of cement, 2 of

sand, 4 of coarse aggregate. A more detailed specification would call for 1 cwt. cement, 3¼ cub. ft. damp sand, and 5 cub. ft. coarse aggregate, the whole being mixed with 5 gallons of water. If the basis is by weight entirely and the coarse aggregate broken stone, then the amounts are 524 lb. cement, 1,277 lb. damp sand, and 2,083 lb. stone, the whole quantity being good for one cubic yard of concrete. For the mass concrete used in filling, these figures would be, cement 335 lb., sand 1,232 lb., and if shingle is employed 2,444 lb., all making up to one cubic yard as before.

The quality most demanded of concrete is its resistance to crushing, its appearance being a secondary matter. The resistance is tested in the laboratory on cubes 6 inches square made in an iron mould. Placed in a testing machine, a load is applied and gradually increased until the concrete breaks up. The mixing of the aggregate for each cube being strictly supervised and recorded, and its resistance to crushing being now known exactly, we have another link in the chain of information.

According to the type of construction, so the strength of the



The Slump Test gives definite information as to the quantity of water in the concrete.

concrete has to vary. It might be required to withstand 3,000 lbs. or 5,000 lbs. test load at 28 days. It is now reckoned as an established fact that when sufficient water is added during the mixing to bring about the actual chemical change in the cement, any further addition tends to weaken the concrete.

A rough test of the amount of water in a mix is the Slump Test. A conical sheet steel can is filled with the stuff to be

tested, a fixed number of strokes with a 5/8 inch ramrod is given, and the can lifted off the pile. The height of this pile will slump by a certain amount, which must not exceed 2 inches for any purpose, and for modern roadwork the specification frequently states " No Slump "—and that is what it means.

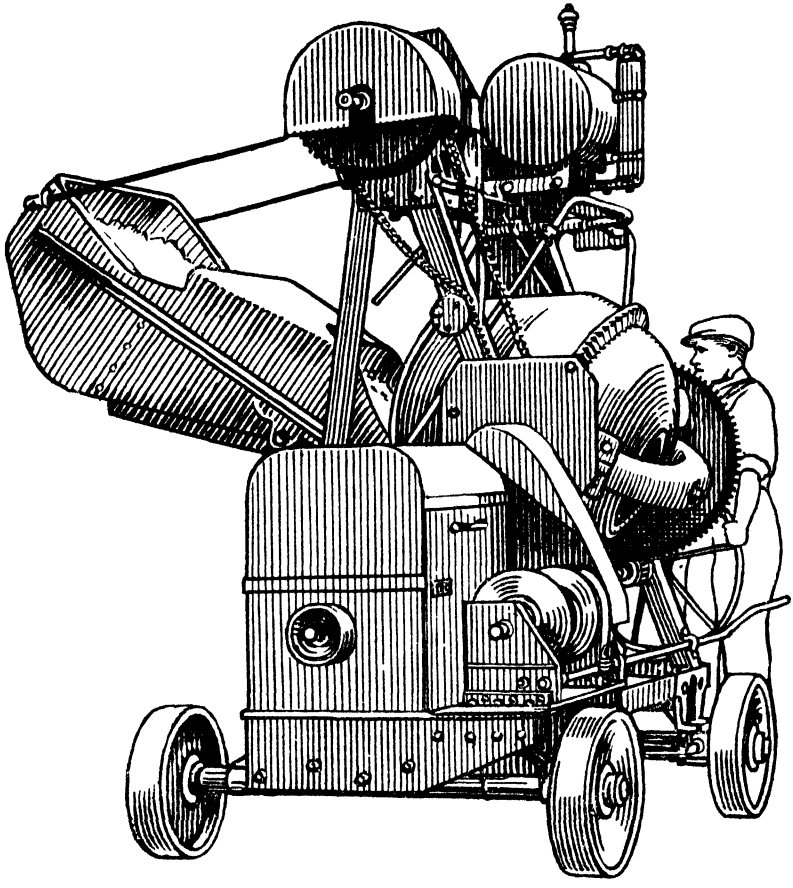
A test of concrete for reinforced floors showed that a mix with 6 per cent. water was good for a resistance up to 1,800 lbs. per square inch. With 7 per cent. water the strength went up to 2,600 lbs., but with 8 per cent. it dropped to 1,600 lbs. per square inch. Just one per cent. water to make all that difference ! That fraction of the five gallons mentioned a little way back is less than half a pint.

In this connection there is another snag. Sand, which is such an essential item in the make-up of concrete, rarely comes to hand in the dry state that the calculations demand. Does that make much difference ? Indeed it does, for taking, say, 100 cubic feet of dry sand as standard, well packed, this will occupy nearly 110 cubic feet of volume if loosely shovelled into a container. Now if it is wet, with no more than five per cent. of water in it, the space occupied will be fully 135 cubic feet. So much for measurement by volume.

It would appear from all this that the simple machine known as a Concrete Mixer will have to be more accurately designed and constructed than our uninformed spectator would have believed possible.

Concrete mixer sizes are stated in a manner that sounds ambiguous to the beginner, but like many other things, clear enough when you know what it means. Specifications may be 5/3½, 7/5, 10/7, 14/10, and these indicate that the drums are capable of accepting the former figure in cubic feet of dry aggregate, and on account of the shrinkage that will occur in the volume after water is added, the actual delivery of concrete amounts in cubic feet to the second figure. Thus : 5 cubic feet of aggregate make 3½ cubic feet of concrete. The second, third and fourth sizes take in 7, 10 and 14 cubic feet and produce 5, 7 and 10 cubic feet of mixture. Of these, the most popular size is reckoned to be the 14/10. Above this size, the machines are described solely on the basis of output, as ¾ yard, 1, 1½, or 2 yards, and except for the ¾ yard machine, are loaded with aggregate by mechanical means.

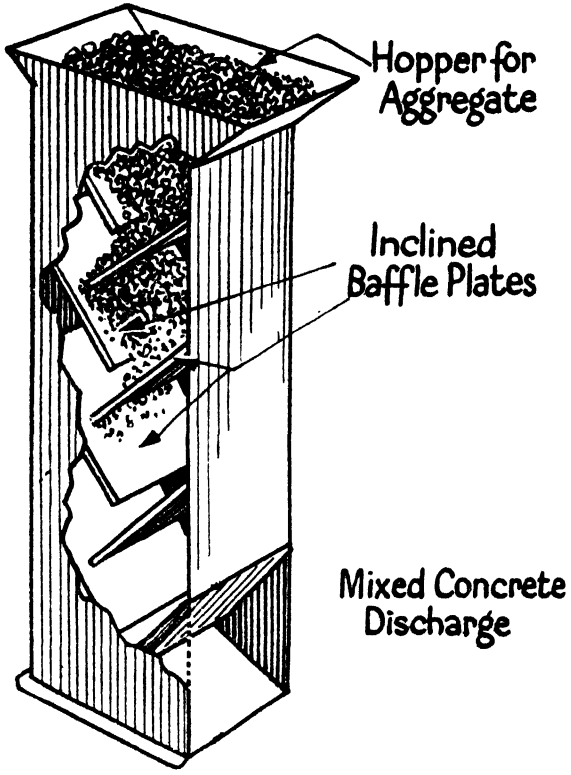
Now, the usual mixing time in the drum is three minutes, and



"The Simple Machine known as a Concrete Mixer."

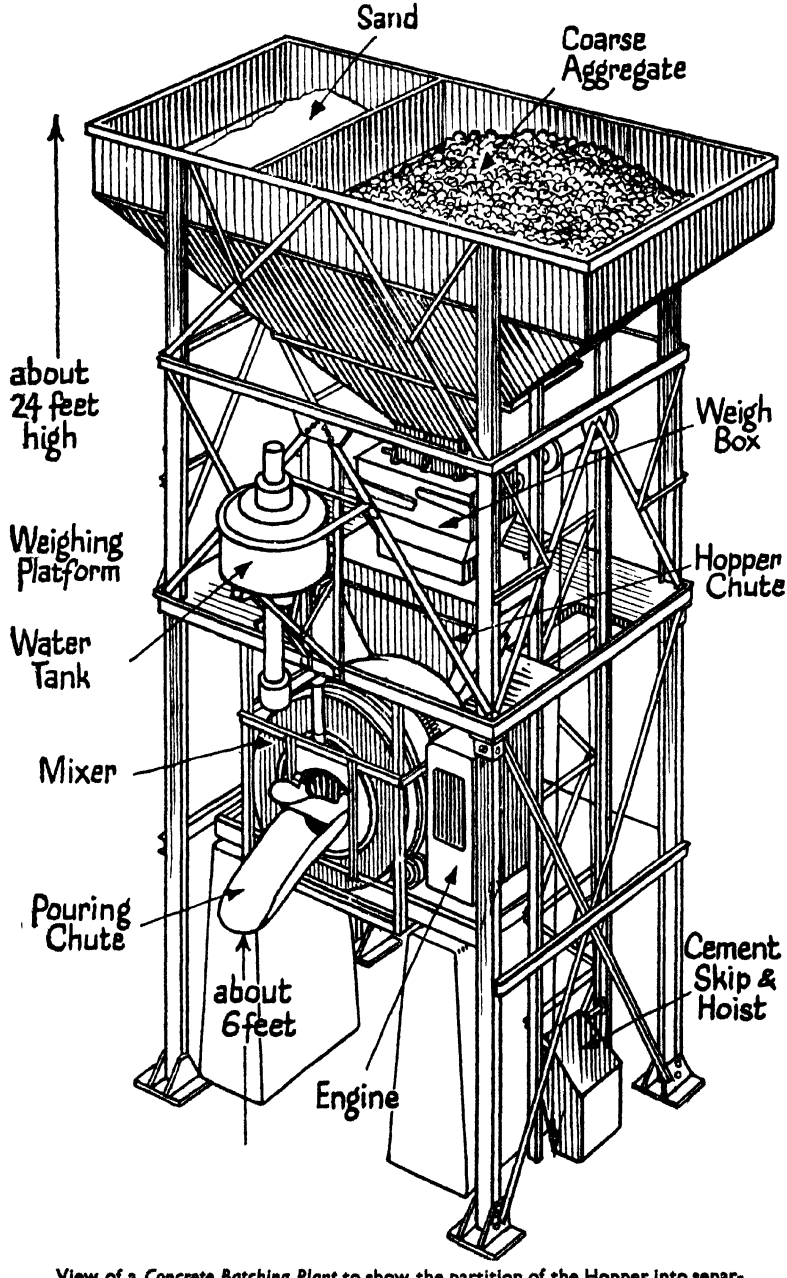
a gang of men small enough to get round the machine and still have room enough to keep out of each other's way cannot load a ton, which is about the weight of a yard of aggregate, with shovels in that time. Sometimes use is made of skips that can be loaded outside the immediate ring by additional hands, and then after picking up by a crane can be tipped into the rising loader of the mixer. Another method is to employ a Batching Plant in which the stone, sand and water are stored in bins high above the mixer, and allowed to run down a chute by gravity into the mixing drum. Here is a diagram of an early idea in this direction, though we have no evidence that it has survived.

It is fully realised by now that there is a good deal of complication about the task of getting a continuous supply of good concrete, more especially where the job is out in the wilds somewhere.



A very simple idea in which the Concrete is mixed continuously, simply by falling from one Baffle Plate to the next in stages.

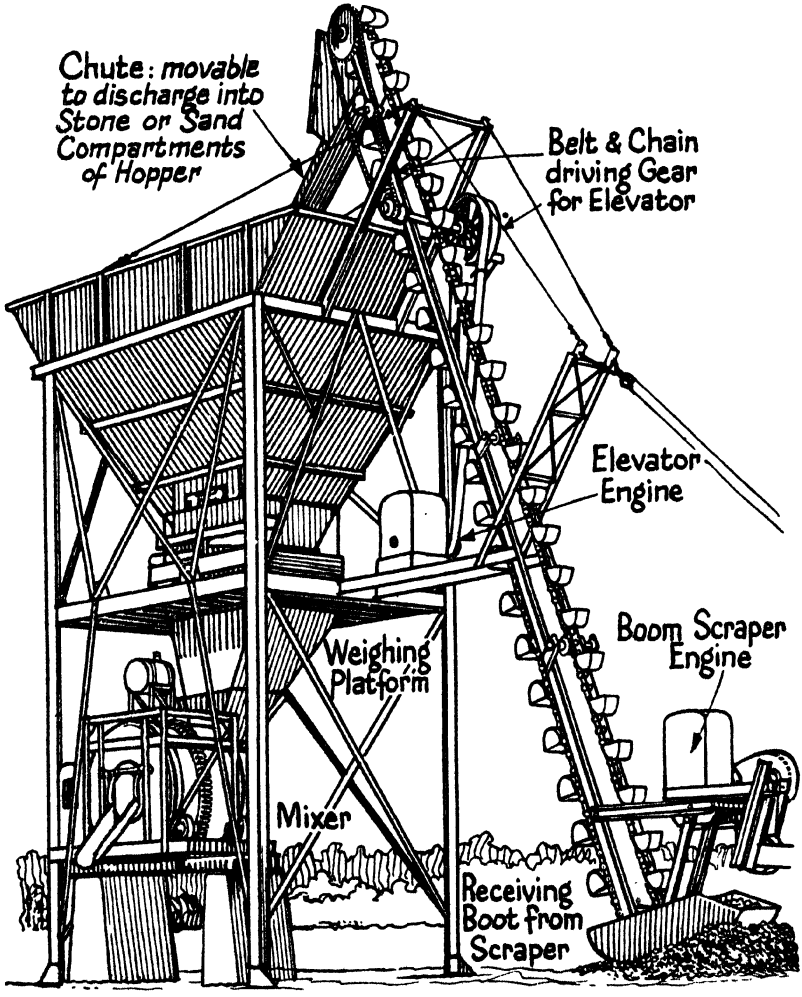
Fortunately, machines to attend to this sort of thing are to be had, though their cost may be thought by some to be more than the work justifies ; as to that, we shall see, there are plenty of them about now. Such an outfit as the one illustrated, a comparatively simple one, will turn out 500 cubic yards of perfect concrete in a day's work, perhaps more. The aggregate will be exactly measured, the water precisely graded, and the whole well and truly mixed. It will cost about £2,000 but this,



View of a *Concrete Batching Plant* to show the partition of the Hopper into separate divisions for Sand and Stone. More than two divisions might be provided in certain cases.

spread over the quantity of concrete represented by a year's working at the rate just mentioned will more than pay for itself, and will at the same time need only five men to run it. More still, it can be dismantled quite easily for transport and re-erection on a contract elsewhere.

The whole idea in the beginning is to have all the raw materials conveniently placed so as to give a continuous flow

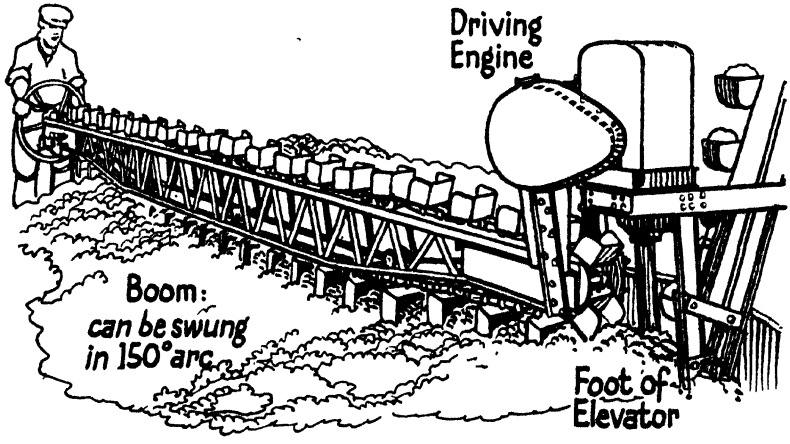


This aspect of a *Concrete Batching Plant* shows the elevator for filling the Hopper with Aggregate.

through the measuring machine to the mixer, and so to the skips or whatever the finished concrete is collected in, thus economising labour. What better arrangement could one have than a big bin placed high enough to ensure gravity feed, with compartments for the various types and grades of aggregate?

At the top of a steel-framed structure are the storage bins, each accommodating about 40 tons of sand and stone, whilst at the back are two bucket belt elevators running around top and bottom pulleys in such a way that the buckets dredge sand or stone from recesses in the floor of large bins. These are kept filled from tipping lorries bringing the material from quarry or sand pits.

If it is inconvenient to use dredging bucket elevators, the stone can be spilled in a large heap and dragged forward to feed on to the elevator by means of a scraper conveyor. This is a simple affair of engine-driven belt with slats on it that each scrape up a little of the stuff, carrying it up to drop into the buckets of the main conveyor. The engine is in the centre, its



A Boom Scraper for loading the Elevator of a Concrete Batching Plant, from a dump.

weight carried entirely on the wheel axle, so the whole thing balances nicely making for ease in handling. Incidentally, many contractors use these desirable machines for loading and unloading jobs, they are to be had in a variety of sizes and forms. Although each bucket takes only a small handful or

so, they keep up a constant movement, with the result that an enormous volume is handled in an hour or so.

From the vertical bucket elevator the stone or sand is turned over to fall into the appropriate section of the hopper. This has sloping sides at an angle of 50° or 60° to ensure that the contents will fall down of their own accord without any attention. For this purpose, the interior is made as smooth as possible with absolutely no projections whatever to give any sort of hold for accumulating stuff.

This condition being assured, it is quite easy to provide for opening shutters at the bottom so that opening them provides a stream of the required aggregate, which can be drawn off in nicely gauged quantity. Beneath these shutter doors is a box called the batch weigher, carefully hung on knife edges with a steelyard scale, so the weight of the different items in the batch can be measured exactly. In some of these machines the weights are displayed on a large dial in full view of the operator. An inspector often sits watching the whole of the work, to make sure that enough cement and not too much water is allowed in a batch, for on these two quantities depends more of the strength of the finished concrete than anything else.

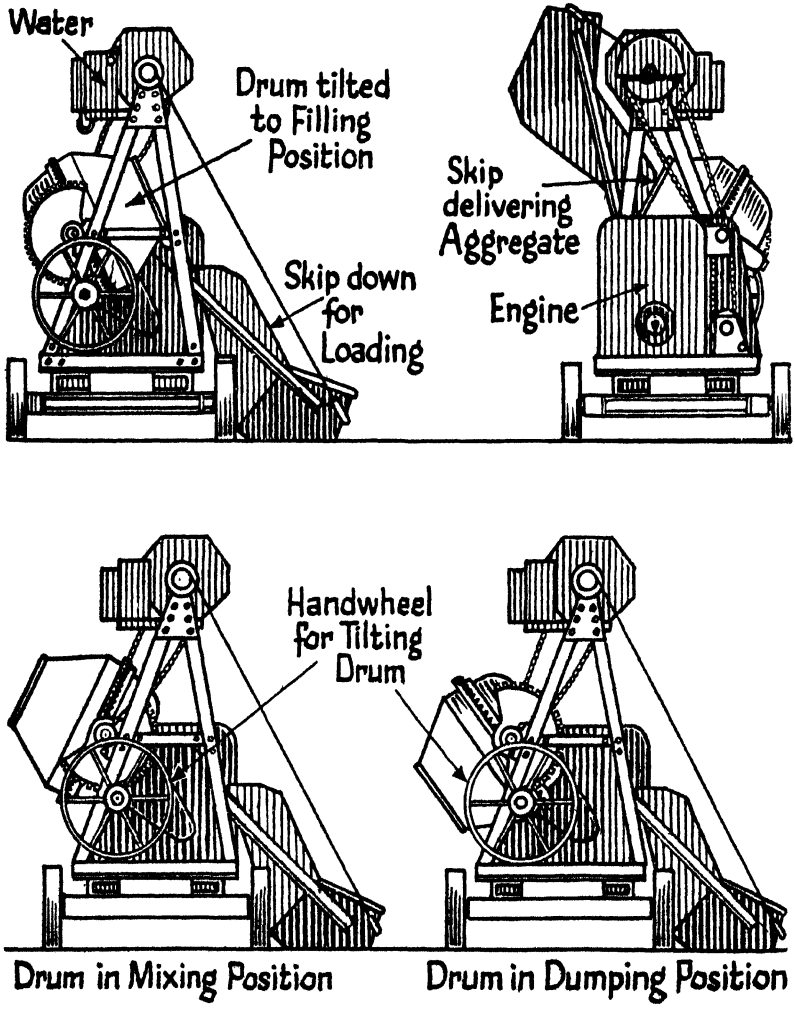
Having let out enough stone, the operator opens the sand door, adds the required amount to bring up the weight correctly, then in with the cement that, in the batch mixer illustrated in the first sketch, comes from a separate hopper entirely. Then finally the water goes in at the same moment that he releases the whole batch from the weighbox to the mixer on the floor below.

This mixer is of the closed drum type, to be described presently. The speed at which this drum is rotated in revolutions a minute determines the number of times the mix is turned over and over on itself, so this matter of length of time in the drum is also watched. Finally another man moves the discharge chute into the mouth of the drum, and this interrupts the falling of the concrete, thus allowing it to pass out of the drum into the waiting wagon.

The cement always provides a problem, especially with these batching plants. It is ground so finely today that it forms an impalpable powder liable to blow all over the place in the slightest breeze, thus being wasteful as well as injurious to the lungs of the men working the plant. One method of solving the difficulty is to tip the bags into a closed steel box into which

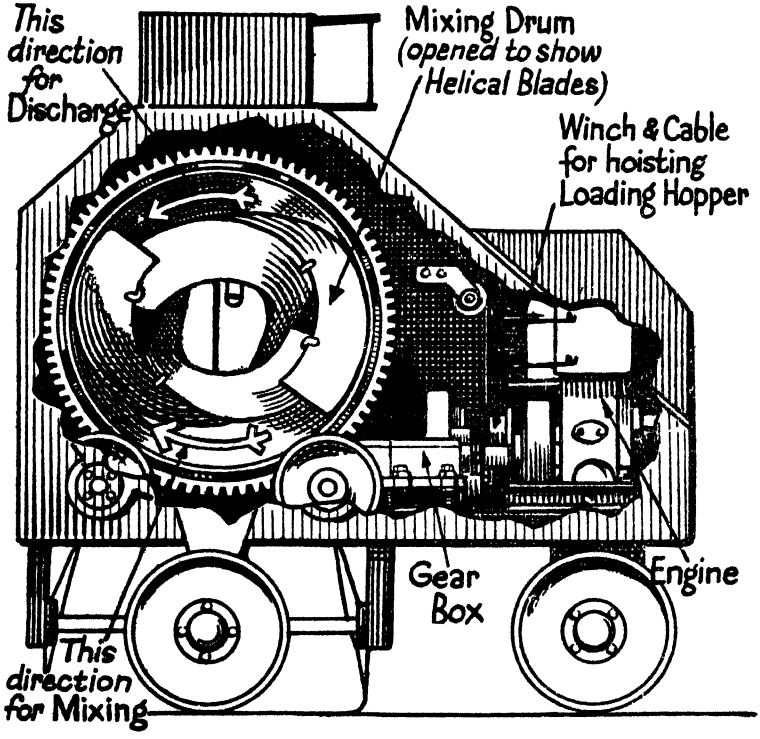
run two pipes. One leads to the cement hopper high up above the batching box, while the other leads from a small air compressor. A touch of a valve and the air blows the cement to where it is required.

Concrete mixers have passed through a long stage of development, and most of the bad features have been designed out of them by now. Every contractor has his own preferences in



Four aspects of a *Tilting Drum Mixer* in action.

the matter, and can tell you most of the reasons why, but it would hardly do to repeat these in a book. The trouble is that even the best machines get terrible treatment on the job by some men, and the indiscriminate bashing of hoppers and discharge chutes does them little good. Generally speaking they can be classed as closed drum or tilting drum types. In the first sort the drum is carried on rollers and the concrete is

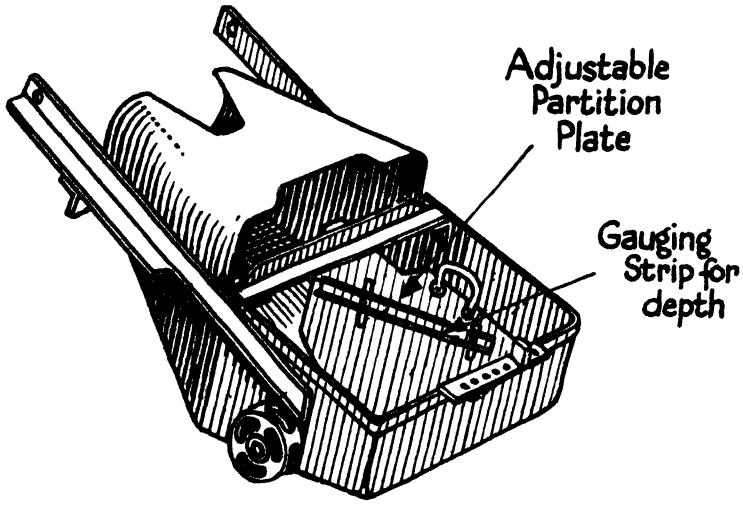


An enclosed type of *Closed Drum Mixer*, with drum opened to expose mixing and clearing blades. Emptying is effected by reversing the direction of rotation.

intercepted by a chute pushed inside the opening, this collects the mix as it is carried round and pours it out. Tilting drum mixers just pour the mix as the drum is rocked on a trunnion. Diagrams show the general arrangement. As a rule, the tendency in concrete mixing is to do it in larger quantities, this being proved the better way ; all the really large mixers are of the closed drum sort.

It would be hard to say just how many varieties of mixers have been put on to the market. Invention in this field has been prolific enough, but it can fairly be said that development has produced the two main types already mentioned. All sorts of bright ideas have been incorporated, the main objective being to secure perfect mixing in the least possible time. To do this the interior of the drum has been most studied.

To ensure proper proportioning of the aggregate, batch boxes are frequently used, a not very convenient arrangement. Here is an idea to save a deal of labour. The loading hopper has a dividing plate that can be adjusted to make two compartments, one for stone and cement, the other for sand. All the men have to do is to fill these with their respective materials and they are then in their right proportions. A gauging strip

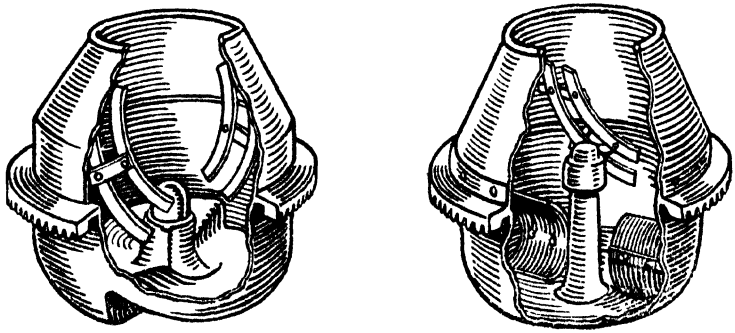


A Simple Gauging Device attached to the Loading Hopper.

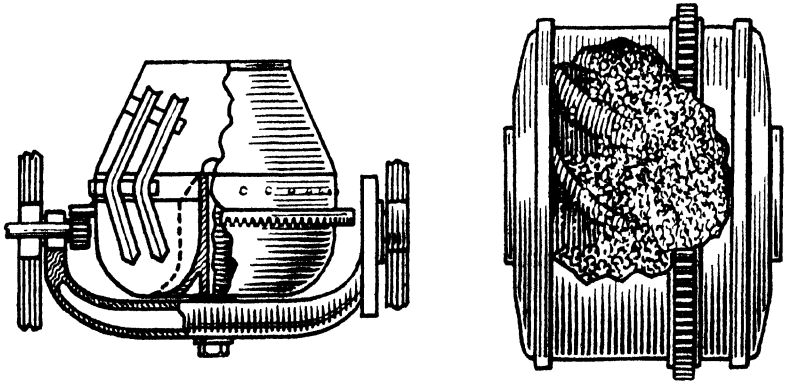
marks the correct depth, and this also can be adjusted by the proper authority.

The aggregate being tipped into the drum without any previous attempt at mixing, some arrangement inside must be provided to comb it out and turn it over and over to ensure adequate and intimate mixing. Some makers set baffle blades inside the drums in spiral form to carry the stuff up to the top,

where it falls down in a shower. Others put in blades of various forms, or chains, but however it is done, the principle is the same and every maker is sure that his does it best. Some of these are illustrated here.



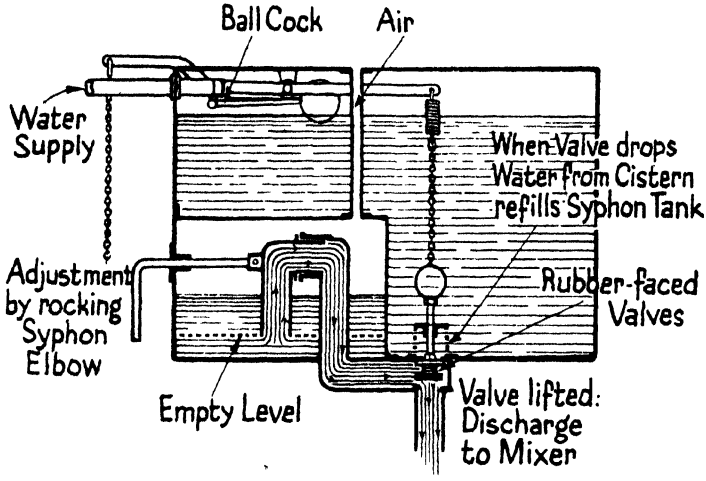
Every Concrete Mixer has a different arrangement of Paddles inside its drum. Here are two Tilting Drums opened up to show this.



Two more *Mixer Drums* opened up to show internal arrangements.

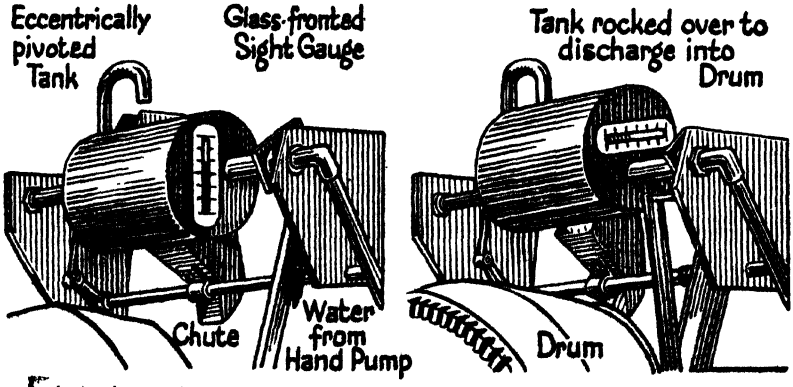
The water supply is an important detail. We have seen that its accurate measurement is essential, but there is another item that is of interest about it. Warm water makes better concrete than cold, especially in winter, so where the mixer is power driven from a portable engine, as most of them are, some connection between the cooling hopper of the engine and the supply tank for the mixer is put in, thus raising the temperature somewhat. A section of a well-known water gauging device is shown. A small tank is built inside the main supply cistern, and a two-way valve keeps this tank full. A syphon pipe

drains off the contents of the tank when the two-way valve is opened to it, and the amount taken depends upon the setting of the mouth of the syphon. Rocking it to one side reduces the quantity. Here again, we shall discover a number of ingenious designs, some of which have been illustrated.



A Syphon Cistern method of water measurement.

The job of up-ending a loaded hopper to tip the contents into the drum is clearly one for the engine, consequently it is usual to fit a knock-out device of some sort, operated by a projection from the hopper arm. This declutches the skip-

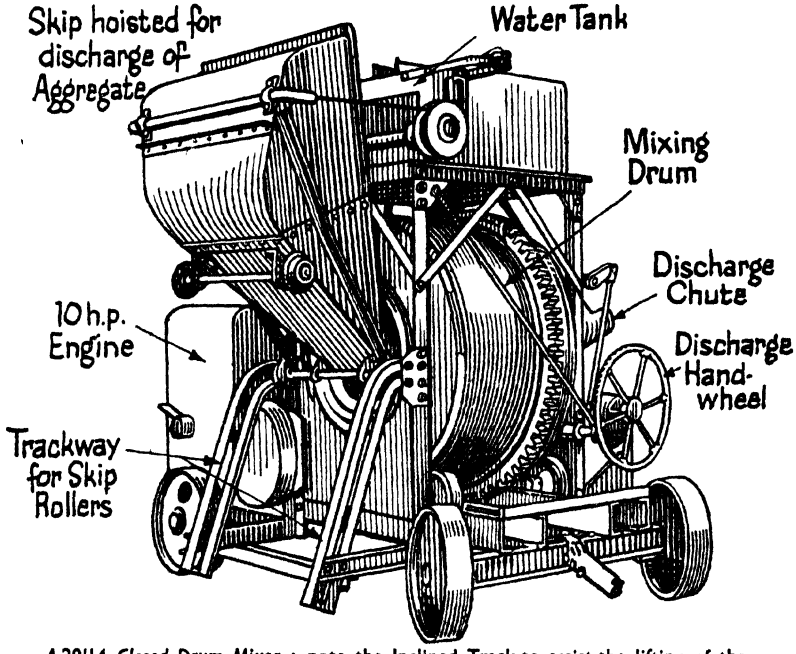


A simple contrivance for accurate measurement of the water supply, and its discharge into the Mixer Drum.

winding pulleys and puts on a holding brake, saving all risk of overwinding.

With tilting drum mixers, the effort required to tilt when emptying the concrete is no great matter, so a geared handwheel is put in for that job. Where closed drum machines are concerned, all that has to be done is to move the discharge chute into the emptying position and hold it there. Again, a handwheel does it, with, in at least one case, a dead-centres locking arrangement to hold the chute in the emptying position.

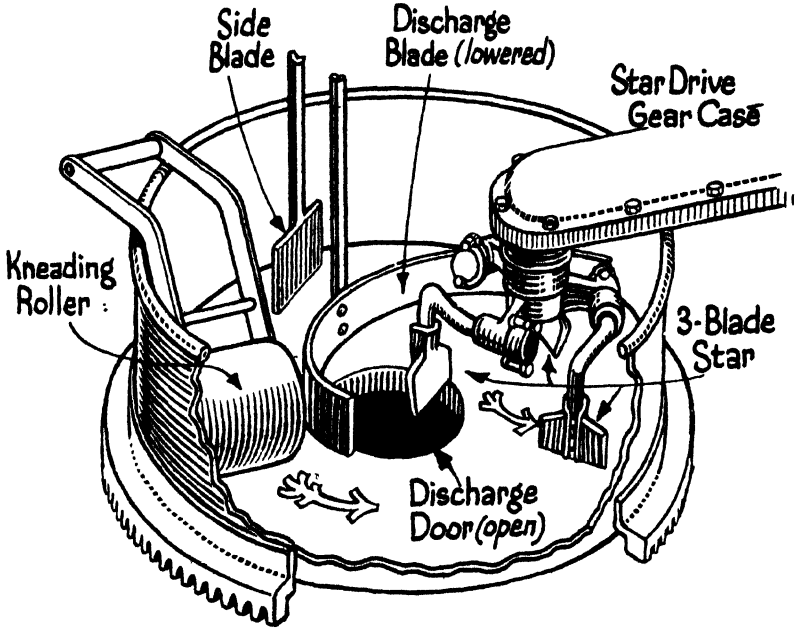
Where large machines of this latter type are concerned, the filled loading hopper has something over a ton of stuff in it, it is usual to put in an inclined track with rollers under the hopper to take the weight when it is being lifted. These are illustrated in the drawing of the 20/14 machine.



A 20/14 Closed Drum Mixer ; note the Inclined Track to assist the lifting of the Loading Hopper.

The remark was made previously that concrete mixers had sorted themselves out into two general categories, and in the main this is true. But in view of the considerable amount of invention that has kept the makers busy, it would be unjust to

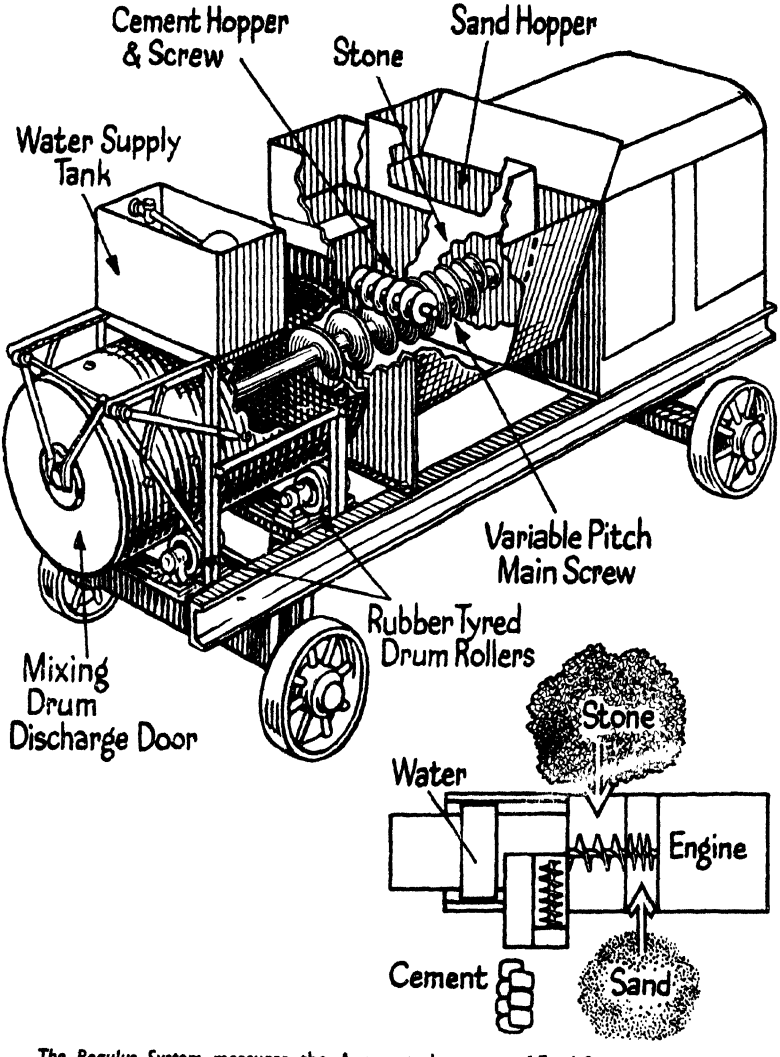
overlook one or two other varieties. The Pan mixer is one of these, and one sort is shown, or at least, that part of it that is a novelty, the pan itself. A hole with sealing cover, in the centre of the bottom, releases the mix when ready, and a spiral blade is lowered to guide the concrete to this hole. The



The Mixing Arrangements of *Pan Type Concrete Mixer.*

work of mixing is done by revolving blades—called a star wheel—in conjunction with the rotation of the pan. In some cases a roller is added, hinged to permit it to ride over the surface of the mix, and this adds a useful kneading effect. The makers claim that half a minute is adequate time for mixing by this system.

A constant stream of mixed concrete has always been an attractive matter for the inventor, and at least one success has been achieved in this direction. A drawing shows an exploded view of a small form of the machine. The stone, sand and cement are fed into hoppers, where they are received by a heavy steel worm rotating near the bottom. This carries them forward into the mixing drum. The pitch of the worm is designed to vary the quantity of material it carries forward ;



The Regulus System measures the Aggregate by means of Feed Screws, giving a continuous output of Concrete.

thus, the sand being collected first, the pitch is finer, but as it passes through the stone hopper the pitch is coarse. In this way it carries double the quantity with it. The screw feeding the cement is a separate item, its speed being adjusted to give a proportion that can be previously decided, various chain

sprockets being available to permit the changing of speeds, thereby altering the general proportions of all three components.

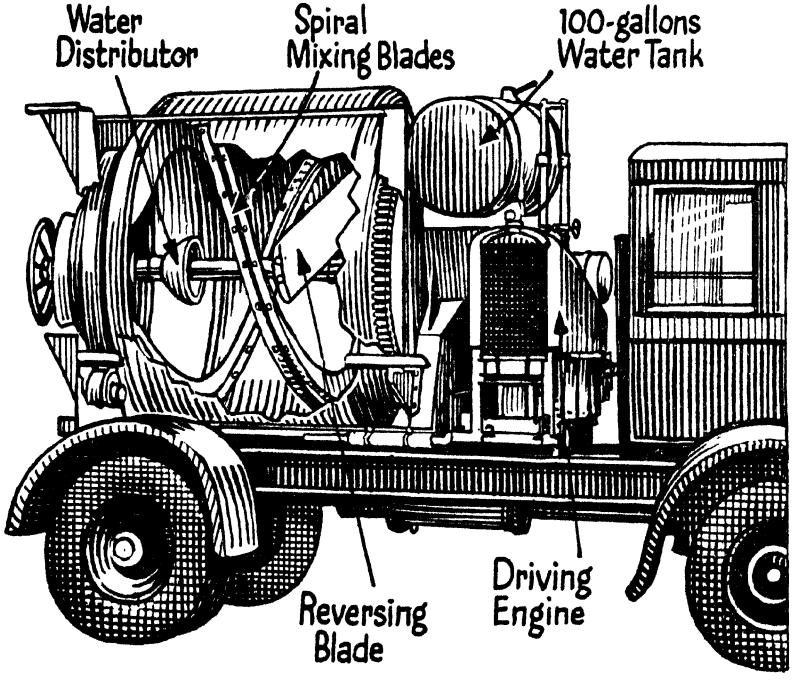
The mixer drum has spiral blades, and as it lies in the horizontal plane, the mixture is thus carried forward, to be discharged at the far end if the hinged door is open, as it normally would be with continuous mixing. It is carried on the same shaft as the feed worm, and makes 25 revolutions a minute. The type illustrated is claimed to be good for 9/10 cubic yards an hour. It is hoped that some idea of the principle of working can be gained by those unfamiliar with the machine from the drawing, from which much detail has been excluded in order to expose the essential works.

The next stage, having got the concrete mixed is to transfer it to the job, which will not as a rule be very far away, though it may be awkwardly placed for accessibility. Where a building is in course of construction, the concrete mixers will almost certainly be located in the basement so as to get as near to a gravity supply of the aggregate as may be. So the barrows taking the concrete from the mixers will sooner or later have to be hauled up to the stages above, where floors and columns are being formed. The almost invariable method is a barrow hoist, a most useful set-up. This consists of a light steel framework with a platform sufficient to accommodate a barrow safely, hauled up and down by a steel rope, wound either on the drum of a special winch, or else a winch built into the concrete mixer and driven by the same engine that drives that machine. A mixer is illustrated on page 170, having such a winch as part of its equipment. These winches are put into engagement by means of a friction clutch, of which a variety of designs are to be found. One very well known machine is also illustrated in the chapter on Piling, this has an annular V-section wood to metal clutch, engaged by sliding the barrel along its shaft.

The customary sizes of these winches have capacities of 5, 10 or 15 cwts., and to run these at speeds of 80 up to 120 feet per minute, engines of 3½, 5 and 8 h.p. would normally be installed.

Whatever arrangements are made to dispose of the concrete once it is so mixed, they have got to be expeditious, for the stuff soon begins to set once the cement has picked up its complement of water. Now, there are occasions where large

quantities of concrete are wanted in places where, to say the least of it, conditions are not going to be favourable for on-the-spot mixing. To meet this sort of emergency, the large-scale producer of concrete came into the picture. Plants were set up in strategic places where materials could be conveniently had, and fleets of lorries of special design put into service to deliver concrete anywhere. These machines are concrete mixers on wheels—they are most of them that, of course—into which a correctly measured batch of aggregate is tipped.



The Interior Arrangements of a *Mixer Lorry*. The water is added a few minutes before the concrete is due for delivery.

During the journey the materials are turned over, and five minutes before the time of arrival—or at any pre-decided point—the necessary water is released and full mixing goes on until arrival at the work. So we have a useful load of concrete, anything up to 4½ cubic yards of it, all ready to hand without the inconvenience of having had to mix it ourselves. A mixer lorry is illustrated, with its drum exposed to show the mixing blades.

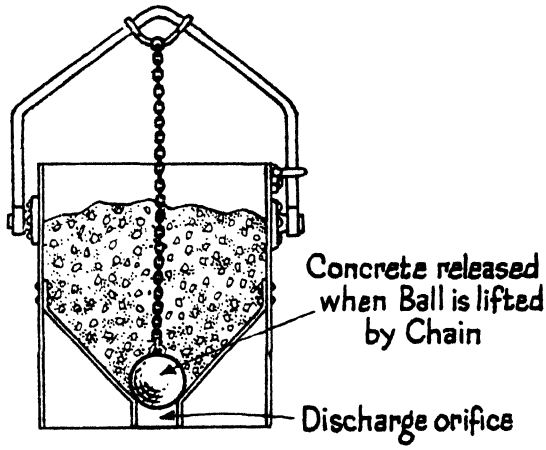
A visit to one of the depots where the material for truck-mixed concrete is prepared will provide an object lesson for the man who is not entirely convinced as to its merits. On the operating platform the visitor would be confronted by a considerable array of levers and a bank of weigh beams, possibly six altogether. As to the levers, we counted ten on a recent visit, five being allocated to the admission of various grades of aggregate. Then the cement supply is provided by compressed air, and shot into the mixture through the agency of a hand-wheel. There will also be apparatus for the determination of the degree of moisture ; this being known for all the items, due allowance can be made for it. The place seemed more like a laboratory than an adjunct to a concrete mixer, but after the experience of normal working in such a plant, one really had to admit that there was something in the claim that truck-mixed concrete sets a standard that should keep the industry on tip-toes to equal.

This system first began to supply concrete to the builder who wanted small quantities and had no facilities for producing it other than by hand, but has been developed enormously in recent times. The large producer has better chances of accurate batching than the builder on the job. Formerly the concrete was mixed before dispatch, put in the lorry to be kept in a plastic state by agitating paddles *en route*, but this way is clearly not so good as one that dumps a load of correctly mixed stuff, having had the same treatment as if it had been done on the spot.

To return to the place where we are mixing our own concrete, what other methods of distribution are to be seen ? It may be that it will be tipped direct from the mixers into large skips, to be lifted by a derrick crane, placed where it can command a considerable area of the contract.

An illustration on page 79 shows one particular kind of crane of great use in the erection of blocks of offices or flats. This is the mono-tower derrick, it will cost about £3,000 and cost maybe £500 to erect, but in spite of that, like most contractors' machinery it will save much more by the convenience with which it handles the stuff.

If the concreting is very special, as in good reinforced work, it is against the rules to drop it from a height, with the result that tipping skips are barred by the inspectors. So use must



A Bottom Discharge Skip for Concrete distribution by Crane. The opening is sealed by an iron ball.

be made of bottom-discharge skips made in several designs, one of which is shown here in section. A large ball seals the orifice, keeping the concrete in until the chain is pulled to lift it, when the load runs smoothly out.

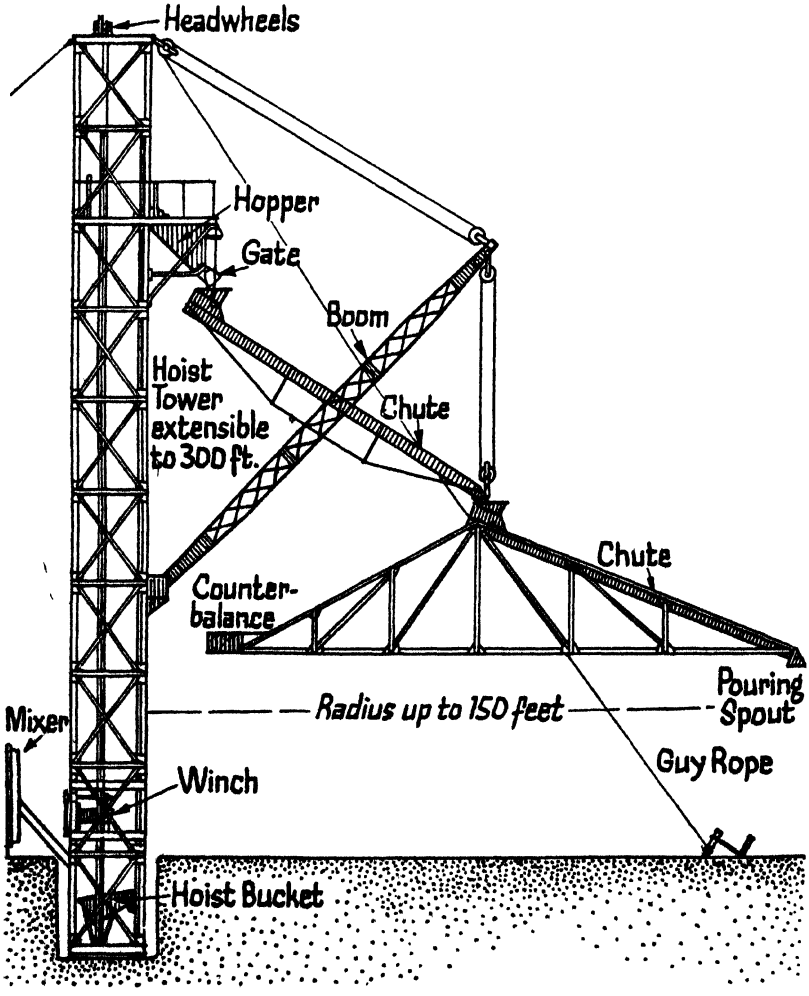
At one time, use was made of tall steel towers, carrying long chutes which led to the required part of the work, so that the concrete being hoisted in a tipping skip could be emptied into a hopper from which it slid down the chutes. The habit of segregation, to which we referred in discussing transport by lorry, makes trouble here, so these chutes are rarely seen now.

A more modern way of dealing with it is to pump it through pipes, a process which would seem to be almost impossible, but it has been successfully carried out.

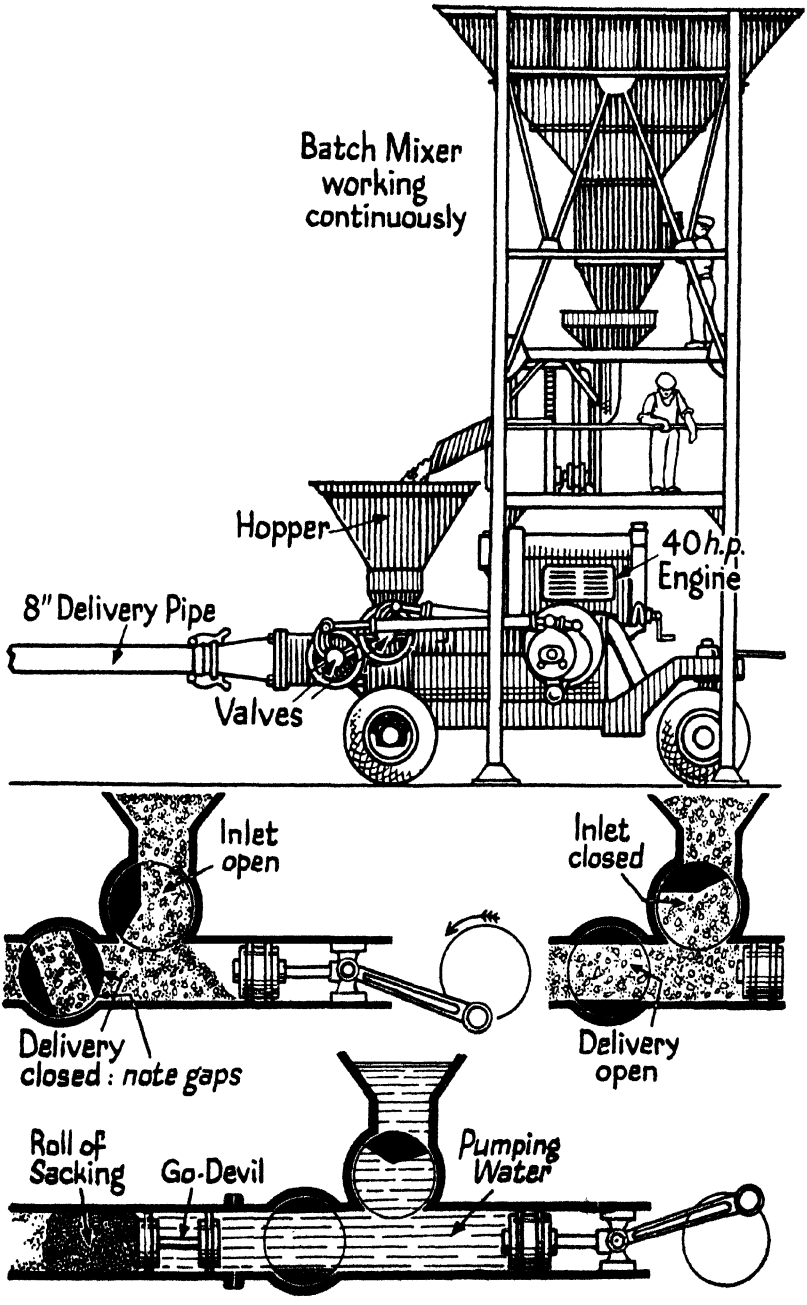
The first essential in a concrete pump is a good hefty engine of at least 40 horse power.

Geared down to a massive cankshaft fitted with two parallel connecting rods, with a piston in its cylinder making the usual to-and-fro movements, the engine speed comes down to about 45 strokes per minute of this piston. There is a large opening at the top of the cylinder, leading to a conical hopper into which the mixed concrete is poured. Closing this opening is a special form of rotating valve, and at the discharge end of the cylinder is another similar valve. The principle of the arrangement can be seen in the diagram. The concrete drops

through into the cylinder as the upper valve is opened, then the rear valve opens and the upper one closes as the piston drives the concrete along the eight-inch delivery pipe. When the piston retires, this rear valve closes and another load is delivered as the upper valve opens again. A simple enough arrangement of course, but there are a good many difficulties to overcome in the working.



Formerly often seen on large contracts, these *Concrete Distributors* are not now in favour.



Above *A Portable Concrete Pump* taking supply from a Batching Plant.
Below : Details of the *Concrete Pump* and its Valves.

The pipe line may be a thousand feet long, including a vertical lift of fifty feet or more. Working on a basis of 120 lbs. to the cubic foot, a fair average for 1 : 2 : 4 concrete using fine sand and sandstone, this pipe full represents a solid load of almost 19 tons. A ton of this will be pushed up vertically, but this part of the work is nothing to a 40 h.p. engine, it is the friction that makes the load, and that can be terrific as may be imagined. Bear in mind also that the load stops moving every time the piston retires, and has to be re-started at each working stroke. Concrete starts to set about 20 minutes after it has been hydrated so the line must not be so long that the set will have started before it gets through. It must be sufficiently workable to enable the men to work it thoroughly into all the chinks and corners, especially where there is a good deal of reinforcement to be buried.

The drawing shows a concrete pump mounted on a portable carriage, driven by petrol engine, taking its supply from a batching plant. This it can keep in continuous production. The drawing also shows the two valves and their alternating positions, it should be noted that these do not shut completely, but leave an opening large enough for the largest piece of stone in the aggregate to pass. This is to obviate the jamming that would occur if the valve tried to close on a lump of stone that was just passing through.

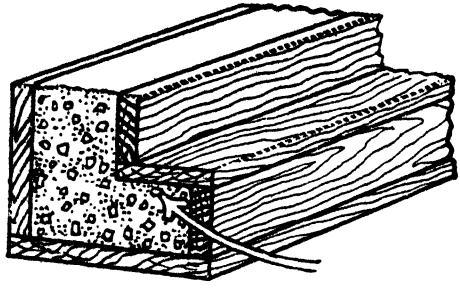
Piping is made up in 10 foot lengths, with some shorter pieces and a variety of bends, together with special draw-off valves so the concrete flow can be tapped at intermediate points.

The inquiring mind will want to know how the pipe-line is kept clean and clear from setting concrete. This is done at the end of every run, with a device to which the picturesque name of "go-devil" has been applied, one of which is illustrated. A bundle of sacking is rammed into the pipe, followed by two of these, and the hopper being filled with water, the engine gets to work. The piston will pump water just as well as concrete, and so the pipe-line can be well swilled out while the concrete still adhering to the interior is still easily movable. Presently we may see these useful machines in general work here in this country, in America they are well-known, having taken part in the placing of some of the concrete in those vast dam-building projects over there in the last

decade or so. Here too, then, it may not be so long before this pump will have really solved one of the contractor's hardest problems, that of placing the concrete after he has made it.

There is another snag about concreting that is particularly noticeable in reinforced work after the shuttering is removed. This is the failure to fill every corner thoroughly, even after quite vigorous ramming. To get over this difficulty, other tools have been introduced, mechanical vibrators, to fairly shake the mass into solidity. Even the best hand-rammed concrete is still full of air pockets and bubbles, and these can never be got out this way. The volume can be reduced by nearly ten per cent. if these pockets can be eliminated.

Again, apart from the natural " voids "—as the empty spaces are called—one comes up against all sorts of awkward places that are very difficult to fill exactly, such as the beam section shown in the sketch, and this is a simple case.



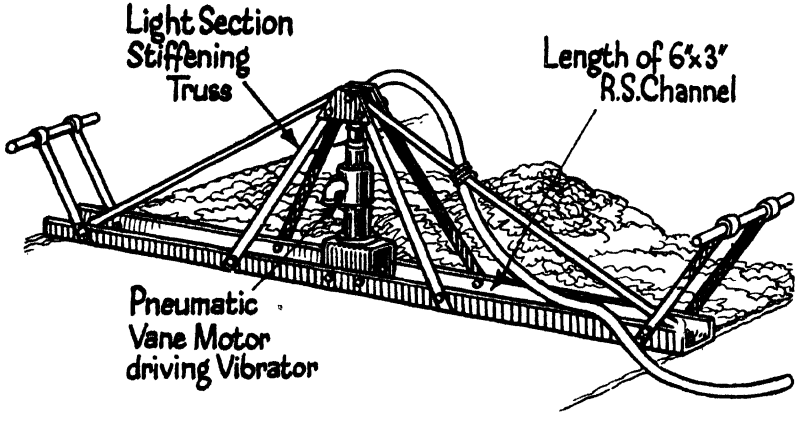
No amount of ramming will ensure getting the Concrete into the place indicated by the arrow. This is a job for the Vibrator.

Mechanical vibration is the remedy for this too. Much pre-cast work, seen everywhere today, is made on large tables kept in a state of vibration by mechanical means. For outdoor construction work at one time external vibrators acting on the shuttering were employed, these might have been pneumatic hammers applied by the men, or else small A.C. motors—or pneumatic motors—clamped to the wooden shuttering and left to run for a time. They vibrated the concrete well enough, but they also did that to the shuttering, which was not invariably good for it.

The usual type now is the Internal Vibrator. This may take the form of a flexible shaft driven by electric or pneumatic

motor, with a flexible casing terminating with a length of stiff shaft enclosed in a steel tube to be buried in the concrete. This shaft has an out-of-balance weight on it that sets up vibration as it revolves at high speed. The higher the periodicity—that means the speed of revolution—the better the work will be done.

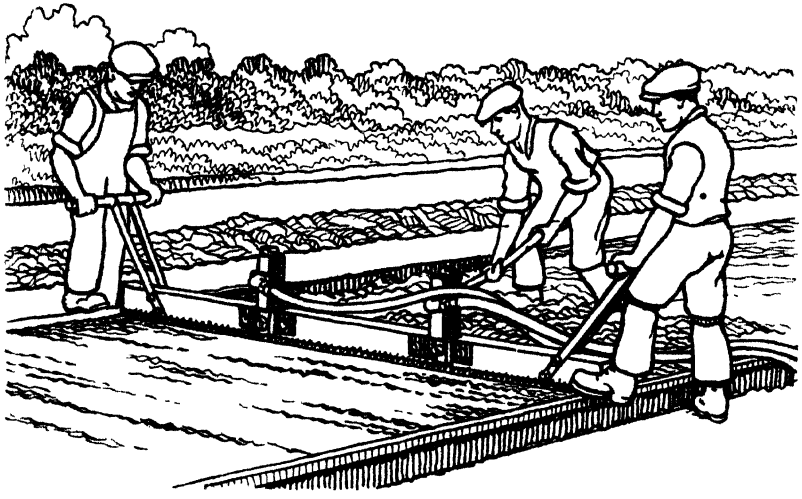
A plant engineer friend who had to improvise a vibrator for large aeroplane hangar floors, laid in bays 16 feet wide, made the outfit shown in the illustration herewith. A length of 6 in. × 3 in. steel channel, braced with light steel sections to



An Improvised Screed and Vibrator made for laying Aerodrome Hangar Floors.

ensure flatness formed the basis. Handles for lifting were fixed at each end. To provide the vibration, a pneumatic vane motor, originally coupled to a water pump with a three-bolt coupling, was set up in the middle, two of the bolts were tightened up in the blank coupling, the other was left out. Run at 6,000 r.p.m. the out-of-balance vibration did the work adequately and quickly.

In road construction this method has long been recognised as desirable, the famous motor roads in Germany were all so treated, and some extremely massive machines were designed to do it. The screed board, by which the surface is formed, will have vibrators attached to it as shown in the drawings. These will ensure a consolidated mass, not only on the surface, but throughout the whole thickness, eliminating the risk of those voids that make for cracking when the really heavy loads come



Vibrating the Screed Board on a Road-making job by means of two Pneumatic Vibrators.

hammering along in the course of the road's daily work. The Spreader Finisher, mounted on rails, now does this work. Engine-driven, it spans the road, spreads the concrete heaped in front of it, tamps and vibrates it, using concrete of the no-slump grade.

Such work is invariably tested today by cutting out, with a special tool, a six inch diameter cylinder right through to the bottom. When extracted, this gives a check on the quality, but also on the thickness, which in modern specifications must not be more than a quarter of an inch out, a fair test of the machine.

This vibrating method has most certainly come to stay, for really homogeneous concrete is the material the architect and engineer bases his calculations upon, but which they have but rarely been able to make sure of until now. Knowing the difficulties, they have had to design their works with much greater factors of safety than were really necessary, if the concrete had been perfect. Presently we shall see a new style in this desirable material, with a lighter and more airy construction, and it will be largely due to the stronger reinforced concrete made possible by the use of correctly applied vibrators.

Yet another valuable tool in the contractor's hands is the cement gun, in which the liquid cement is sprayed on to almost

any sort of surface, to coat it to any thickness that may be desired. . This is the Gunite process, successfully used in many ways. It is employed to reface and repair old faulty concrete, the pressure being sufficient to fill up all cracks and voids and then to face the work with a strong and enduring shell. It has been used to coat the wooden piles of old harbour works, even below the water line, making old work far better than new. Lining tunnels, that have to carry water, with a smooth frictionless surface is easy; coating steelwork also, but the uses of the device are manifold.

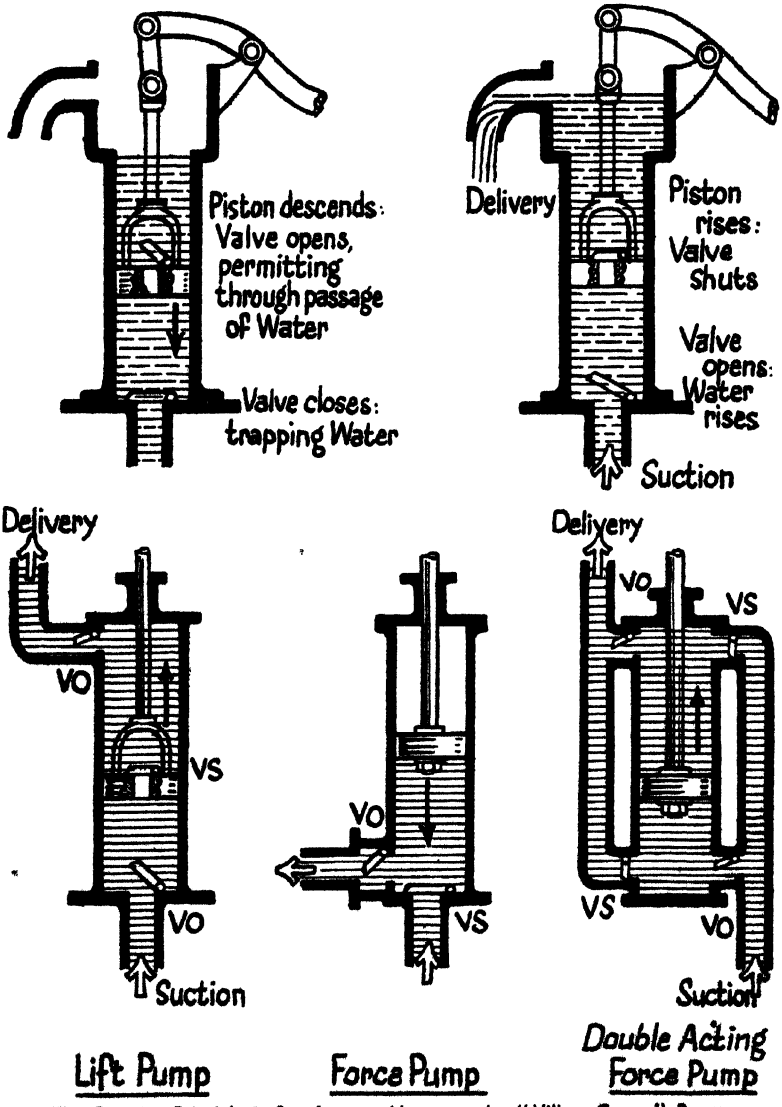
Gunite is made up from cement, sharp sand and water, one of cement to three of sand being thoroughly mixed and carried by a blast of air into the gun nozzle. Here a number of fine sprays of water provide the necessary water for hydration and the mixture is shot out in a spray jet. The air pressure used is about 35 to 40 lbs. per square inch, the quantity of water can be regulated to a nicety, but it is not necessary that the mixture should be very wet. All that is required is sufficient workability to enable it to catch on and stick, any tendency to flow is not much desired. As a rule a thickness of one inch is adequate, the Mersey tunnel was lined throughout its underwater section to this, on a steel wire mesh secured to the concrete. Up to 1½ inches has been applied in some cases.

Chapter 9

PUMPS.

THE subject of water has cropped up in every chapter of this book so far, and this is not surprising for water is with the Plant Engineer all day and every day. Either he wants it or he does not, but which ever state he may be in, he can be sure the water is not where he does want it. That being the case, he has got to arrange for it to be moved and almost invariably the pump has to be set to work to do the moving. Various occasions have been described in these pages where water has had to be moved, sometimes in very large quantities. The de-watering of a site may involve hundreds of thousands of gallons a day, and this has to go on non-stop perhaps for months. A reliable pumping set must be regarded as an important piece of contractor's machinery, but there are many kinds of pumps, and a whole book could well be written around them.

Though it might sound impertinent to ask the question, we should like to inquire whether everyone really knows the essential parts of a simple pump—of the village green type—and how it works. For the benefit of those who are not too sure, a page of diagrams is offered here. On it can be seen the motions of the simple suction pump. The Barrel is open at the top, with a pouring spout, and the piston—more technically described as the Box—contains a simple flap valve that opens under pressure from below and shuts under pressure from above. The suction pipe at the bottom of the barrel is provided with a similar valve; the pipe descends to the water supply below, which must not be more than 25 feet down.



The Pumping Principle in five forms. Above are the "Village Green" Pumps, simplest of all; below are developments, culminating in the continuous flow Force Pump.

Now why is this ? Simply because it is the pressure of the atmosphere that pushes the water up the pipe in response to your attempts to create a vacuum under the box, and at sea level this pressure is theoretically equal to a column of water 32 feet high. In practice it is found that this height is not attained, even 30 feet is somewhat uncertain, 25 is a more usual figure.

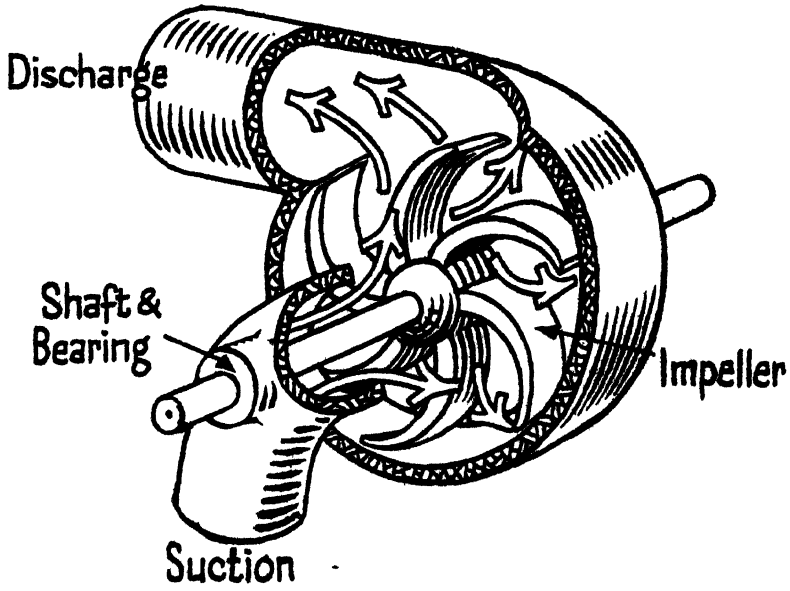
This atmospheric pressure does a lot of quiet unobtrusive work for us that we do not always realise, but its action is more often forced upon us when it is to do with raising water from a deep well than other occasions perhaps. If the well is more than 30 feet deep, then another type of pump must be employed, and if we are still limited to the simplest sorts, then one of the three shown in section below will have to be put down the well and worked with a long piston rod and delivery pipe. Given power enough, the water can be lifted any height within reason by a force pump so long as its suction valve is not more than 25 feet above the regular surface of the water. Some of the artesian wells in London and elsewhere go down to a depth of more than 400 feet, though the water rises in the bore to a level about 150 feet below ground. To get the water out of these, the pump is lowered below the surface ; it was usual to put in machines with long connecting rods that had to be counterbalanced by correspondingly heavy weights, and many of these are still at work, being very reliable. Latterly the submersible electric motor has taken the place of this arrangement, a most ingeniously designed affair with a completely drowned motor driving a centrifugal pump with three or more stages. Of this, more comes presently.

In the diagrams of simple pumps the valves have all been shown as of the hinged flap type, these being the oldest—perhaps—and the easiest to understand. Entirely automatic, responding to very slight alterations of pressure on either side, they will work for generations as many a village pump could testify, were it possible. Employed more frequently today is the ball type of valve, equally reliable and even more simple, so long as it is made of bronze or other non-corroding metal. Also found in some pumps are flat mushroom types with rubber discs.

So much for the simple pumps, though in actual fact the most elaborate ones are really simple too. The double-acting

design has all the essentials of a big steam-driven reciprocating pump.

If water has to be shifted, there are, generally speaking, two ways of doing it. Either we push it or lift it out of the way, or we throw it. The pushing sort we have seen for the moment, but throwing sounds crude. Yet this is the method most often used where really large quantities are to be handled. The Centrifugal pump is a comparatively modern device, dating from the time when fast-running rotary machinery came in.

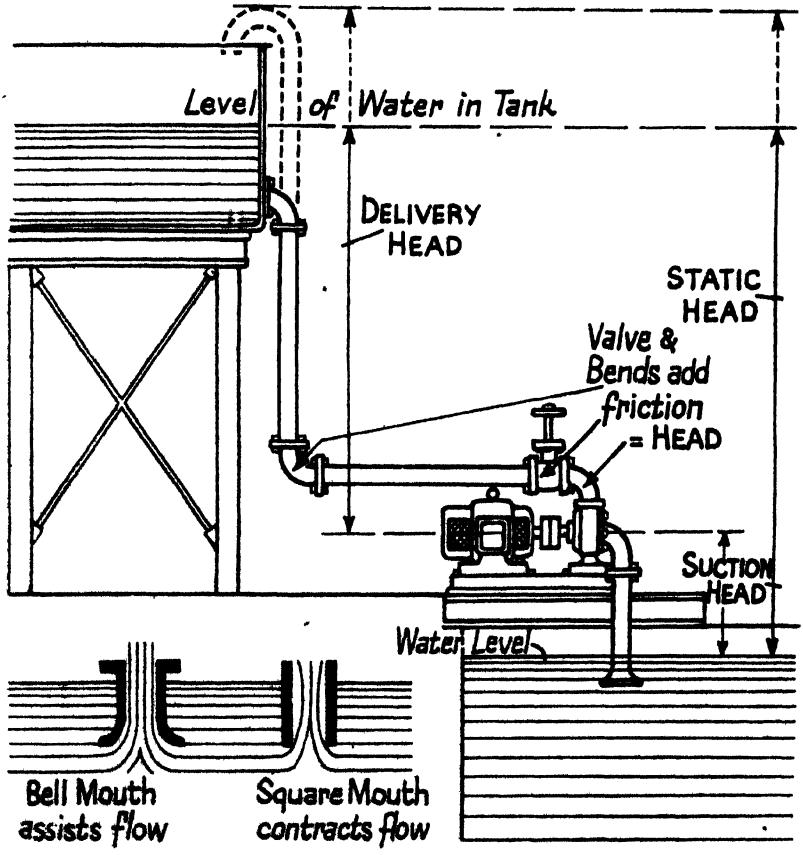


The spinning impeller actually throws the water out of the Discharge branch in a *Centrifugal Pump.*

First of all, however, there is something about the moving of water that has to be fully understood by all whose work it may be to take part on the job, and it will certainly not be long before the new hand at the work has to get at it. The expression "Head," will soon be mentioned. What exactly does it mean?

Quite briefly, the head is the difference in level that the pump has to overcome; that is the easiest way to look at it, but to the beginner there are quite a few catches, so here is a diagram to explain some of them. In actual practice there are three

levels to be considered, but the two principal ones are those of the water to be lifted and that in the tank to which it is being lifted. Between these two lies the level of the centre of the pump. The total head—in theory—is the height between the two principal levels ; in practice a good deal has to be added to this, allowing for friction inside the pipes, bends, valves and the like. Unless the assembly of suction and delivery piping is very carefully arranged the actual head in practice may easily



Some explanation of the term "Head" is here offered.

run to 50 per cent. more than the theoretical, or directly measured head.. So if we have to shift a volume of water through a height of 50 feet, it will be as well to call it 75 feet and run the pump accordingly. In any case, the evidence will soon

be forthcoming, in the shape of water delivered, if conditions are right, or not delivered if the pump cannot make it. In the latter case it may be only a question of speeding up the pump revolutions, so long as the specification guarantees the capacity of the machine to deal with the necessary head.

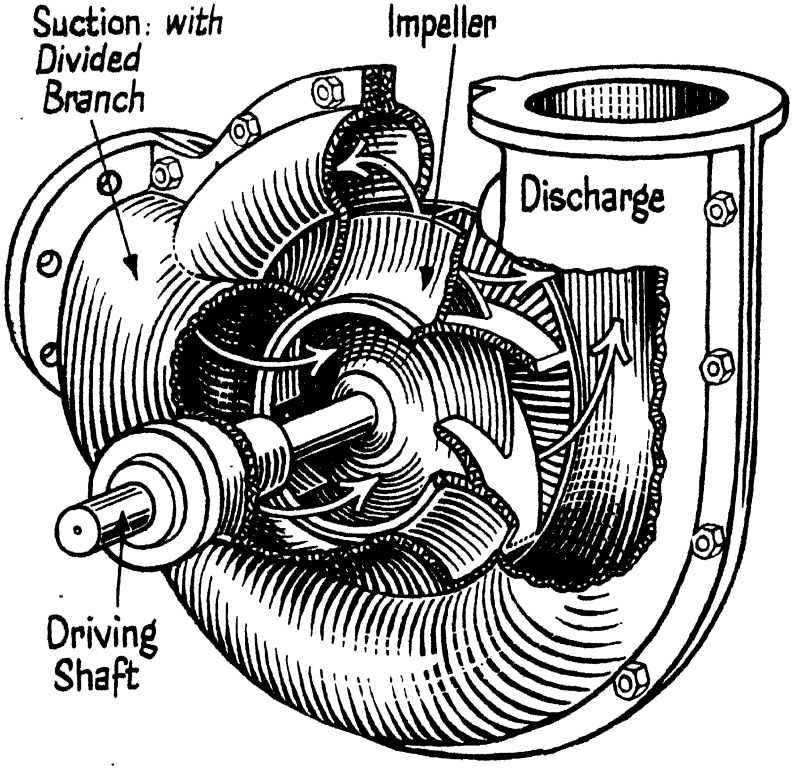
Note that the suction head is the distance from the level from which the water is being drawn, not from the depth to which the suction pipe is lowered. Also remember that a bell-mouthed end to this pipe is far more efficient than a square ended pipe. As the water level drops—if it does—so the suction head increases.

Similarly, the delivery head may be either of two—see the diagram. If the pipe turns into the bottom of the tank, then the head is reckoned to the rising level of water inside. If the pipe is formed with a bend to deliver above the surface of the tank, head is measured to the top of this bend. The two added together make the Static Head.

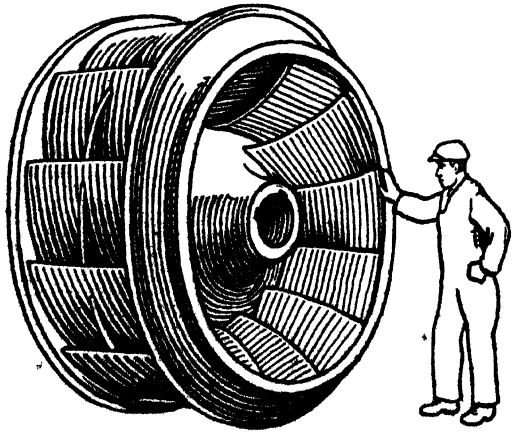
Tables are provided in handbooks to enable the engineer to calculate the Gross Head, that is, the head after all obstructions to a straight flow have been taken into account. This is a very useful thing to be able to do, and very necessary with a permanent or semi-permanent set-up, but it is not often that he will have time to go into it with that degree of detail in a field job. All he will be able to reckon is the approximate head, and knowing what gear he has available, put in the pump that is at least a size larger than seems necessary. Relaying may be done also. The contractor of today has an enormous variety of pumps of a portable description, with direct coupled petrol engines that can carry on for hours, or run by compressed air or steam if these are available. Let us now go on to the pumps.

Undoubtedly the Centrifugal is the most valuable type available today, though it cannot do everything, it can shift enormous quantities of water and go on doing it continuously just so long as its impeller is kept turning. They are built in a greater range of sizes than most other pumps, from tiny ones to keep water circulating in the cooling systems of motor car engines to vast machines designed for emptying harbour docks, or even larger, like the huge pump installed at St. Germans to keep the River Ouse on the move. Incidentally a motor car could be driven along the discharge pipe of one of these !

There is a good deal of variation in the design of these pumps,



Exploded View of a *Centrifugal Pump* with the usual form of Spiral Casing.



Some idea as to the size of a really big Centrifugal Pump can be gained from this drawing of the Impeller of one of the St. Germans pumps.

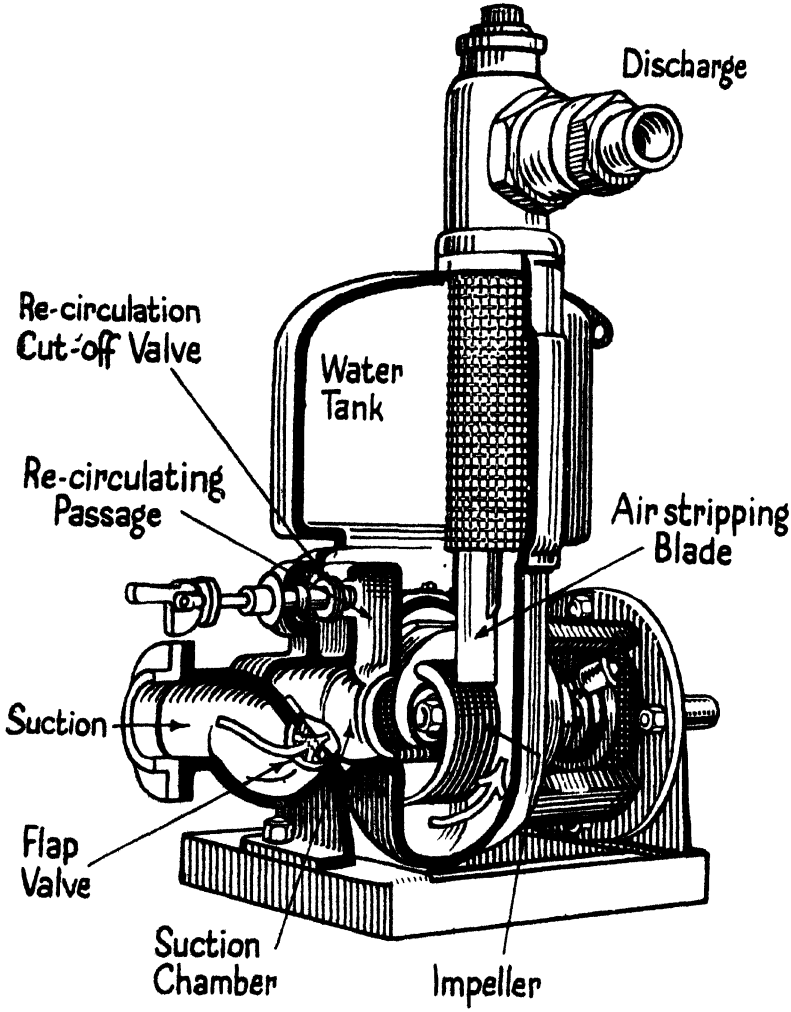
according to the purpose for which they are required, but the idea is the same, to get hold of the solid water, spin it round so that it is flung outwards into a spiral casing into the delivery branch. With small pumps the paddle blades are of helical form as shown in the drawings and of simplest construction, the centre being open so that water can flow straight in and be caught.

We stated just now that there might be things the centrifugal pump could not tackle. There is just one in particular, and that is its inability to draw water up by suction if its casing is dry. Not much thought is needed to come to the conclusion that the spinning rotor has no power to create the necessary vacuum to suck water against even one foot of suction head. So, this being realised, everything else is simple. If we fill the suction pipe and pump casing with water, the spinning rotor sets this on the move, and as the water enters the delivery branch, a vacuum tends to be set up on the suction side which atmospheric pressure on the surface of the water being pumped will attend to. All we require to get is some form of pump that can create a suction, and to fill the centrifugal with its aid, and if a stop valve is added to the delivery branch close to the pump, on a permanent installation, water can usually be kept in the casing to deal with temporary stoppages.

Why use the centrifugal then, if the other sorts are necessary to get it to work? Answer—because no other type really comes up to it for the efficient moving of large quantities. The Ram Pump is a piston pump, very good indeed, able to handle anything, many contractors use them. There is just one thing though, set to pump a ditch dry, unless there is someone to watch out the job may be completed sooner than anticipated, and the pump will run hot and possibly seize up with no water to draw. But we have not done with centrifugals yet.

This business of priming—as filling the pump with water is called—is dealt with in other ways with the little portable machines one sees everywhere. Often a tank is fixed on top of the pump and this is kept full of water by the pump itself, or some device is put in to make the rotor act as a vacuum creator. This is shown in the drawing herewith.

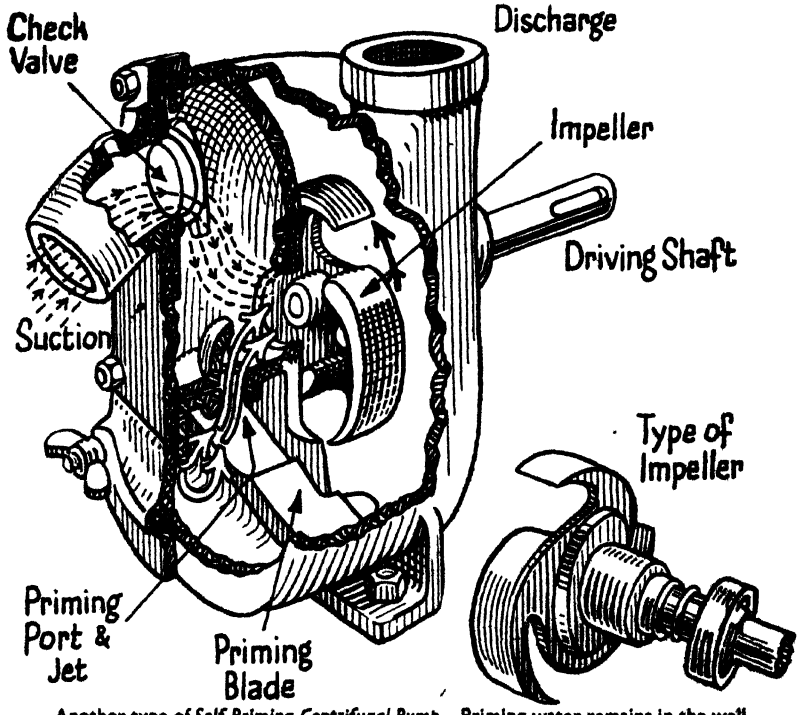
Note the simple shape of the impeller, which enables it to handle a fair proportion of solid matter. There is a tank above the casing, which is filled with water and an automatic flap



This Centrifugal Pump will prime itself, as it lays up a supply of water ready for the purpose.

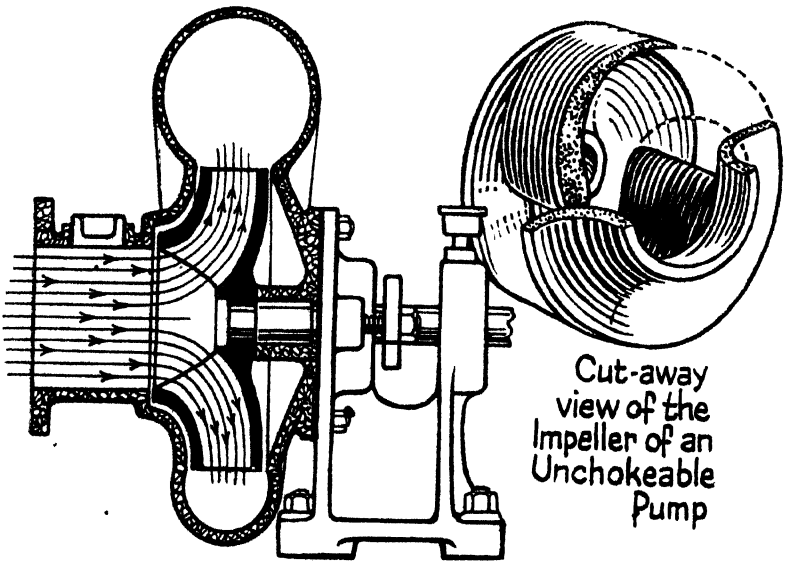
valve seals the suction side to prevent the water from running out at that end. A priming control valve allows this water to flow into the suction casing, and the impeller running, throws this back into the tank quicker than it can return by way of the control valve. So a vacuum is set up, the flap valve lifts and air comes in to mix with the water. There is a steel blade set

in close proximity to the impeller which has the power to strip off the whirling air and divert it into an escape passage. But the water goes into the tank and round again. The vacuum process is repeated in quick successions, the water being drawn up the vacuum box a little at a time until it is in the pump casing, when pumping really begins. When this happens, the automatic priming valve closes and the circulation ceases. The air-stripping blade, however, continues its work, dealing with the one thing the centrifugal is least able to cope with in the ordinary way, that is, air.



Another type of *Self-Priming Centrifugal Pump*. Priming water remains in the well at the bottom of the casing.

Another example is also illustrated. This also has a flap valve sealing the suction pipe, and a priming blade to open or close a special priming port. Enough water is retained in the casing to make a start, and this is driven in a strong jet through the uncovered priming port, producing an ejector effect that sucks air past the sealing flap valve. Thus the water in the

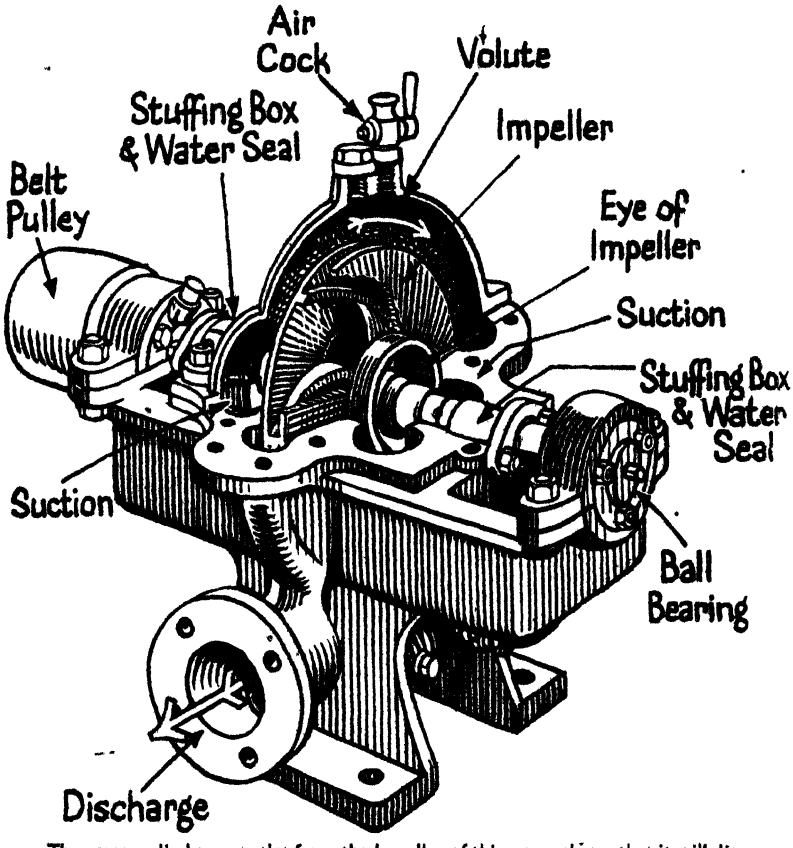


This type of Pump Impeller can take on almost any kind of solid matter, even rags, without risk of choking.

suction hose is gradually drawn up until it reaches the casing and full pumping begins.

There is a good deal of variation in the types of impellers. For a pump to handle a lot of water without the necessity for a high head, the impeller will be open, and this will enable it to take on solid matter in considerable quantity without damage. On the other hand, if *pressure* is wanted, the ability to achieve a high head, then the outlets from the impeller will be narrow. This ensures a high velocity, the same volume may go through, but as the outlet is smaller, it has to travel faster.

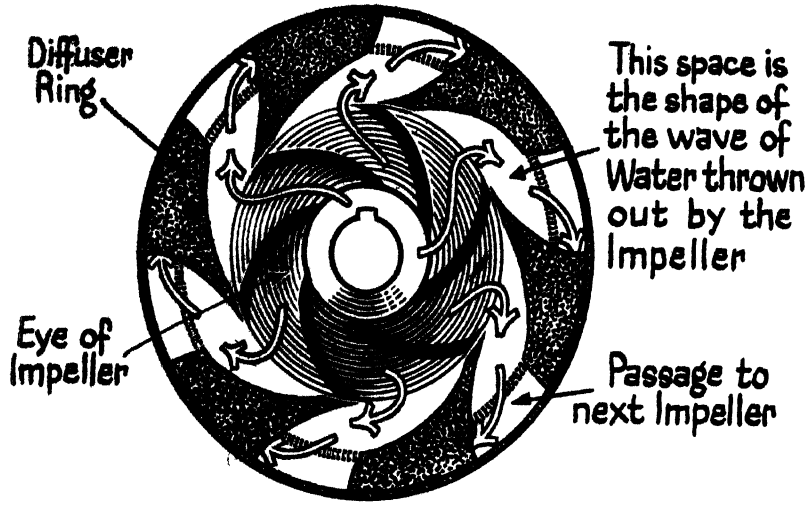
For fire pumps, where the jet has to attain considerable height, compound impellers will be used in all probability. Here two or more are cast together with surrounding passages of an intricate form, so that the first one discharges into the second, and so on, an increase of pressure being gained at each stage. This system is by no means limited to fire pump use, however, as it will be found in many contractor's equipment, being valuable for high head work—say 250 feet. To reach this, the speed has to be somewhere in the region of 3,000 revs. per minute.



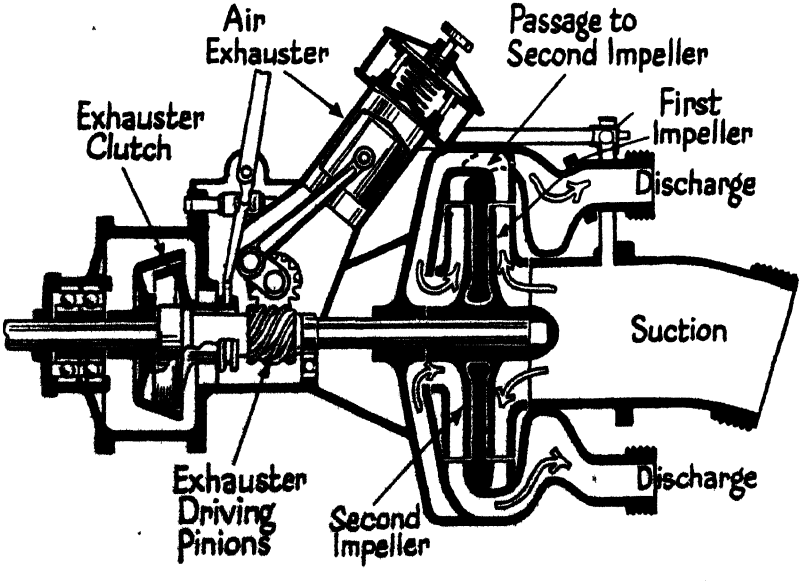
The narrow discharge outlet from the impeller of this pump shows that it will discharge at high velocity.

The water comes into the pump either on one side only, or better still, with a divided branch, that is on both sides of the impeller. This latter arrangement takes out any tendency to end-thrust. An exploded view of a pump shows some of the details. Owing to the intricate nature of the water passages, sectional drawings of these pumps do not tell much to anyone but those with the ability to quickly understand such layouts.

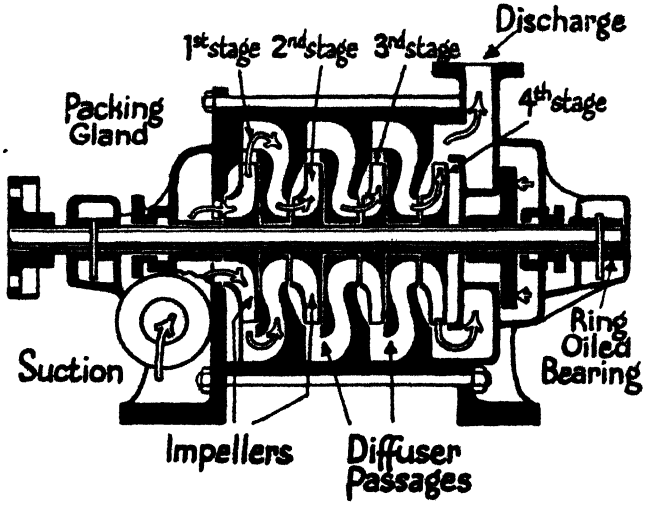
Another drawing illustrates a four-stage pump, of a sort that might be installed down at the bottom of a deep shaft for drainage purposes. The section has been much simplified, and a little study will soon show the uninitiated reader which are the fixed parts and which the rotating impellers. Now there is



A cross-section of Impeller and Casing of a Centrifugal Pump to indicate the form of the discharge passages in one stage of a Compound Pump. The Diffuser Ring leads to the next stage Impeller.



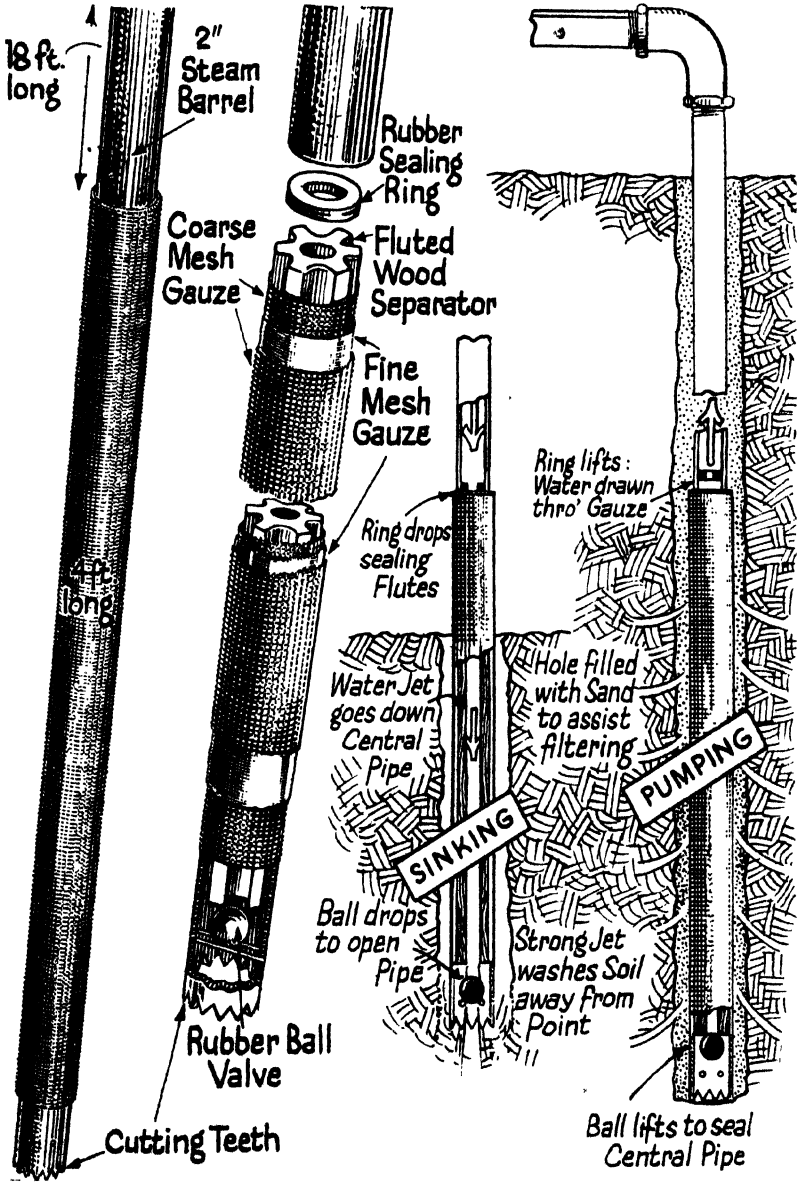
This section of a well-known Fire Pump shows it to be Two Stage Compound with Air Pump to create the initial suction where that is needed.



A Four-Stage Compound Pump in Section.

always a certain amount of end-thrust even with one impeller, and as we cannot here divide the flow of entering water, the end-thrust must be balanced somehow. A flange, keyed to the shaft at the discharge end takes care of this, a certain amount of the high pressure water is admitted into the closed chamber in which it runs, and this checks the tendency of the shaft to move endwise in a rightward direction. For deep mine drainage centrifugal pumps are built with ten or more impellers, fourteen is the highest number in the writer's experience.

Once more we must go back to the question of priming. It is quite clear that the methods we have previously mentioned would not do for big units. So plant engineers use a Diaphragm Pump to prime their big pumps, a screw-plugged hole being provided by the makers for this purpose. In the case of, say, a fire-engine that may have to attend a rural fire where the water has to come from a river or pond, some better arrangement is desirable, to say the least of it. In one design, an air pump is mounted above the impeller casing and driven through a cone clutch, this draws all the air out of the suction pipe, quickly bringing water into the pump, this principle has been used in cases where a good deal of air is likely to be present with the water, as for instance in de-watering sites preparatory to construction work.



The Well Point in construction and action. By encircling a waterlogged site with these, the ground can be dried out to permit of excavation and concreting

Mention of this de-watering again seems to justify a little more detail of it, especially as it is so much of a pumping job. The well-points used—previously mentioned in chapter 3—are lengths of steel tube 2 ins. internal diameter, 18 feet long, with an extension of four feet made up of three layers of brass wire gauze wrapped roung a shaped wooden former—see the drawing for the exact shape. The middle gauze layer is very fine texture, the inner and outer ones are coarser and are to support the fine screen in between. At the top of the wood former is a rubber ring large enough to seal off the flutes in the wood former and at the bottom is a rubber ball to act as a plug valve to close the central orifice. This is kept by a pin from dropping out.

At the top of the tube is a bend to which a hose from a high-pressure pump can be coupled, the pump must be capable of throwing at least 300 gallons a minute. A 4 inch pump, driven at 1,400 revs. per minute by a 15 h.p. engine will do this.

When the water is turned on, it goes straight down the pipe, throwing the rubber ring down, to seal off the gauze, and making a powerful jet at the bottom. This quickly washes a hole into which the well-point sinks, deeper and deeper, until with astonishing luck, the whole 22 feet are buried. As it goes, the water washes out a hole much bigger than necessary, perhaps 8 inches in diameter, and this will be filled in with sand of a coarse texture. This acts as a secondary screen in addition to the wire gauze.

These points would be put down at intervals of 3 feet, according to the degree of wetness expected. Some adventures in getting them in are experienced by most plant engineers who have used them, and it may be said that they do not invariably go down as just described.

As soon as all are in, each has a swinger arm, made up of pipe fittings with a stop valve, fitted. These are connected to an 8 inch main on to which screwed sockets have been welded. The sections of this main are joined up by rubber sleeves and clamping rings, and one end is tightly sealed off.

The open end is coupled to a pump of a size according to the number of well-points put down. It would not be smaller than 6 inch, and it has to be capable of dealing with a good deal of air.

Supposing for a moment that all the well-point pipe couplings are good and leak-proof, then when suction begins, the rubber

balls will rise and seal the points. The rubber rings also rise under the suction, opening a way for water through the gauze screens. The fineness of the gauze keeps out all grit and dirt and the water comes out clear as crystal. As a matter of fact, these points are frequently used for getting supplies of domestic water in America.

On the pump a reciprocating air pump will be mounted, driven by reducing gears, and this must run continuously. A vacuum gauge ought to be fitted, and should read not less than 26 inches. If it falls below this, then there is most likely a leak in one or more of the swinger arms ; as such a leak can soon get worse and represents wasted power (and fuel), it must be located. Each swinger arm can be tried out by shutting down its stop valve. Once they are all tight pumping can go ahead.

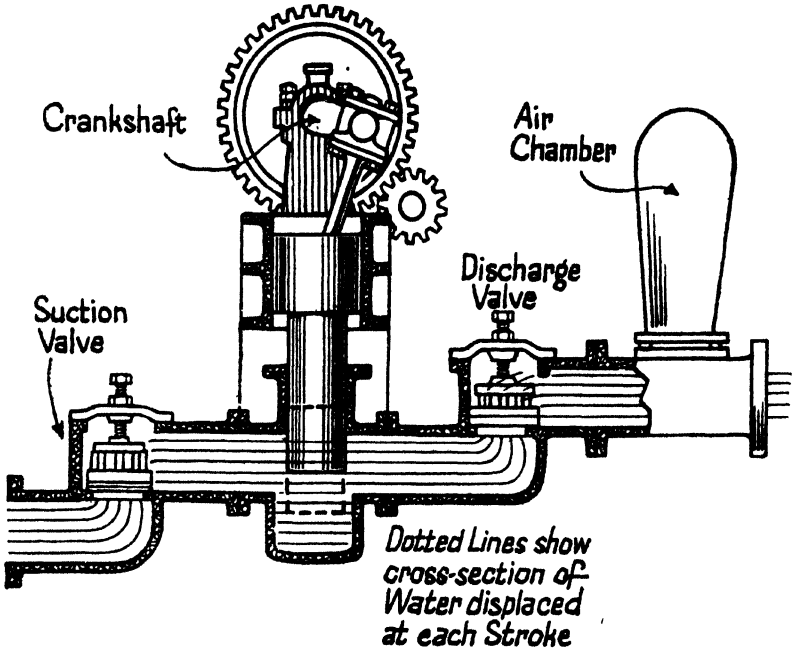
To drive a pump big enough to deal with a possible 80,000 gallons an hour will call for at least 45 h.p., this is perhaps the largest size the average contractor will have in his yard. This, coupled to the well-points and running 24 hours a day for 6 months is going to use up about 36 tons of fuel, and at 1/- a gallon this means £800 for fuel alone. Added to this is the fact that the plant must be duplicated to allow for cleaning and overhaul, as well as for possible breakdown, and it can be seen that de-watering is expensive. But it does make work possible that could not be done without its aid, and so it goes in as part of the contractor's regular outfit of machinery. Other systems of dealing with this sort of difficulty were mentioned in a previous chapter.

We make no apology for so much mention of centrifugal pumps. Every contractor who does much of this pioneering work—as it may well be called—knows what a part pumps play in the whole scheme, and there will be a considerable number of such machines in his equipment. They vary in size from the handy little portables driven by compact, air-cooled, direct-coupled petrol engines, able to look after themselves all day, to big 8 inch (suction pipe diameter) fellows calling for 40-50 horse-power engines or electric motors to keep them going. In this respect the comparison between the size of the power unit and the pump is more remarkable perhaps than with any other sort of machinery.

Much more could be said about the various types of centrifugal, but others have been mentioned earlier in this chapter,

and to the beginner, maybe their working is not so thoroughly understood.

Amongst these is certainly the Ram Pump. The usual form is a very compact arrangement with one, two or three cylinders —or what look like cylinders, with a heavy flywheel, driven by an engine through reduction gearing. An extended section of



Section through a simple form of *Ram Pump*.

such a pump, to show the sequence of events through one unit, is shown here. The remark about cylinders can be understood from this, for the pistons can be seen to have extensions that are immersed in the water chamber and by their up-and-down movement alter their displacement, creating suction and pressure in alternate rising and falling. The valves are automatic and are usually of the rubber and grid type illustrated here. Pumps of this sort are self-priming and will draw water from the maximum depth that any pump can reach ; they are very reliable—so long as lubrication and packing leathers are kept in order. As already mentioned, it is not good for them to be left at work pumping away at nothing at all, as there is

always a possibility that the ditch that pump was set to clear is not so deep as was thought, make sure that it has an eye on it from somebody !

The Diaphragm Pump comes next, certainly, it ought to be considered as one of the most useful portable types in the

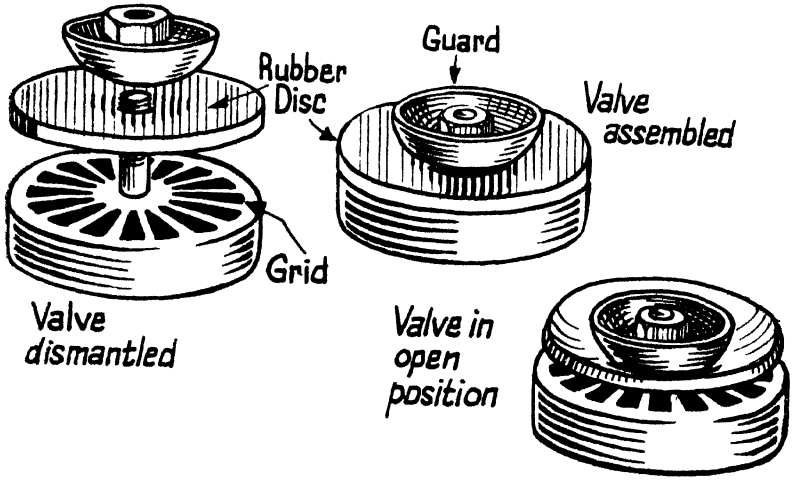
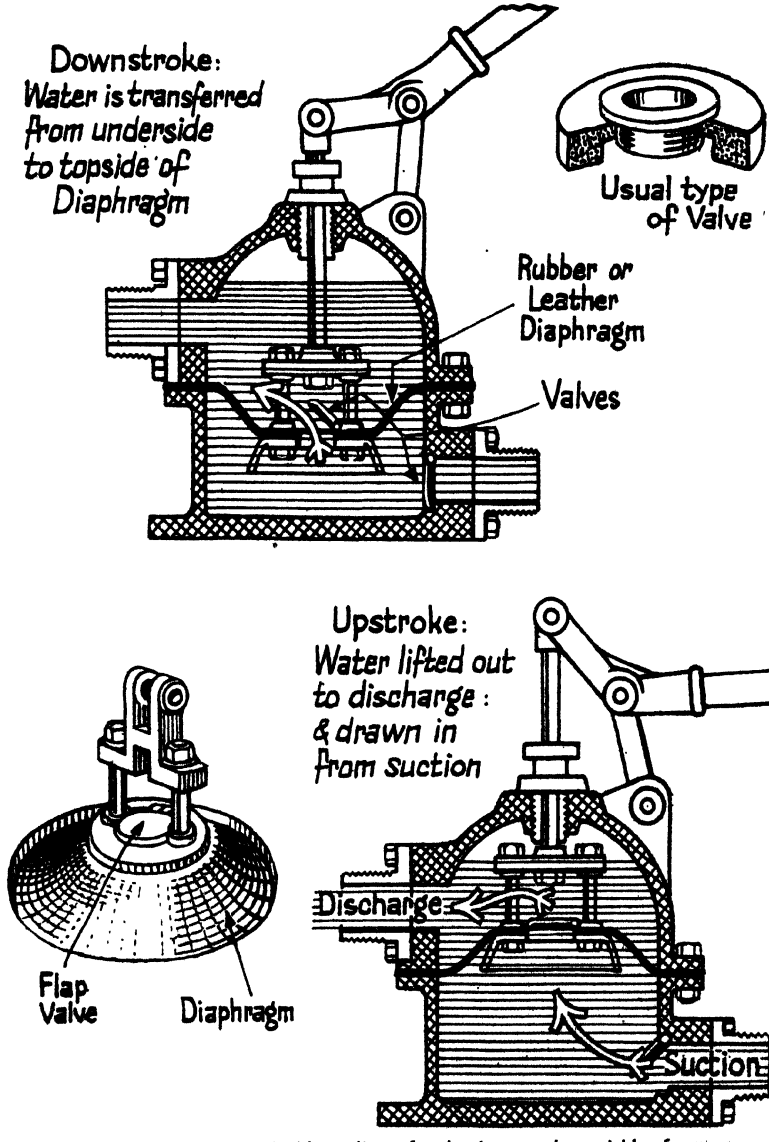


Fig. 154.—*A Simple Form of Valve* for use with any sort of water pump.

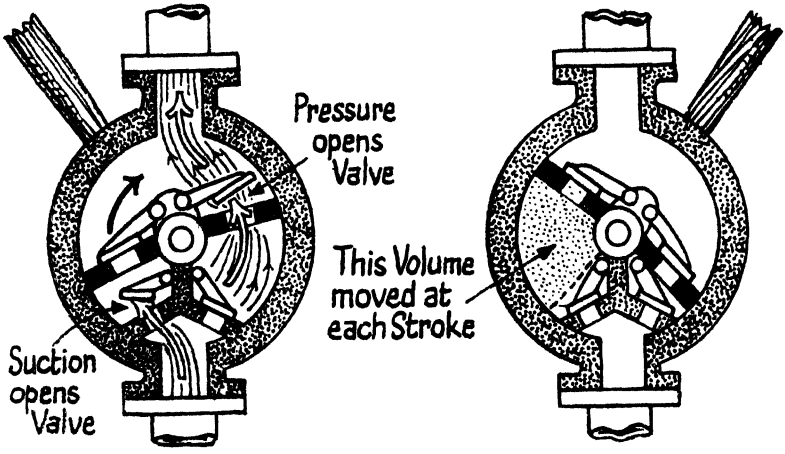
equipment. As a hand-operated water-moving device it has no equal, and can be seen on the job everywhere. It does not care how dirty the water is, and some types with valves of the flap variety can handle a fair size of solid stuff. The drawing shows the idea well enough ; the varying displacement is set up by a disc of leather, or special rubber, with a valve in the centre, firmly secured to the pump all round. These pumps are sometimes made with open tops and a spout, to discharge into a trough, or they may have closed tops and a discharge pipe. In the former case all the head they will deal with is on the suction side of course, but with closed tops, they will force lift to any reasonable height. As they are not really intended for this latter purpose, too much should not be expected of them. For emptying trenches or pits they are very good indeed, especially where there is only hand power available.

Of a totally different sort is the ingenious design called a Semi-Rotary. The circular casing is divided into two partitions the entry to each of which is controlled by flap valves. Pivoted



The Diaphragm Pump is a valuable appliance for clearing trenches quickly of accumulated water.

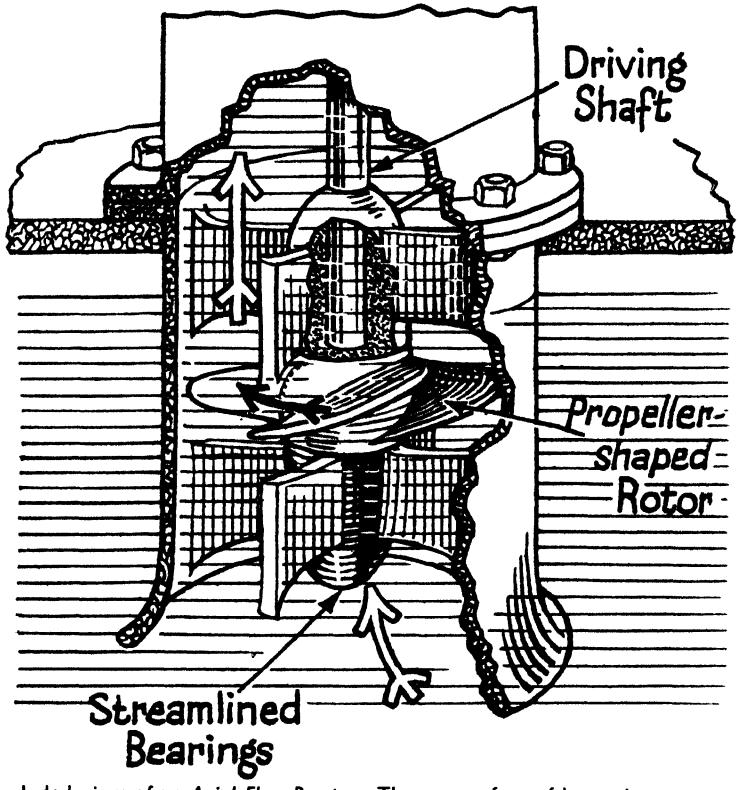
at the centre is the double piston of rectangular section to closely fit the casing. It has a similar flap valve on each wing. All the valves open upwards; the sequence of their action should be clear from the drawing. A pump of this sort will lift a full 25 feet if required, and force 70 feet, but they are not usually wanted for such a task as that. But they *can* cope with the work that diaphragm pumps do, and are often found fitted



Action of the Semi-Rotary or Wing Pump.

to concrete mixers, or to centrifugal pumps for priming purposes. A pump that will do more than is ordinarily expected of it is always useful to remember in an emergency.

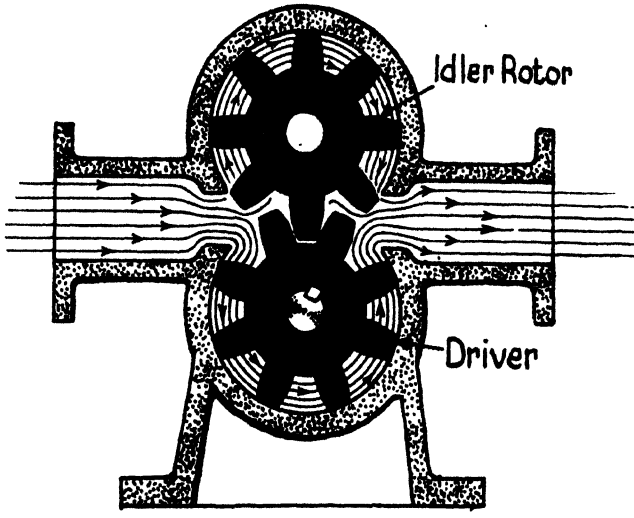
Amongst the fully rotary pumps, as distanct from centrifugals are some interesting forms, the most powerful and useful of which will surely be the Axial Flow Pump. A simple form of this is illustrated. It consists of an impeller shaped exactly like a ship's propeller, mounted in bearings in a tubular casing. There are no valves of any sort, and the direction in which it runs decides the direction in which it pushes the water. It is completely unchokeable, and will take on anything that water will bring through its casing. Some very large axial-flow pumps are at work in various places in the world, and owing to their freedom from choking, they are much employed in handling sewage. In such a duty the rotor would probably be mounted horizontally.



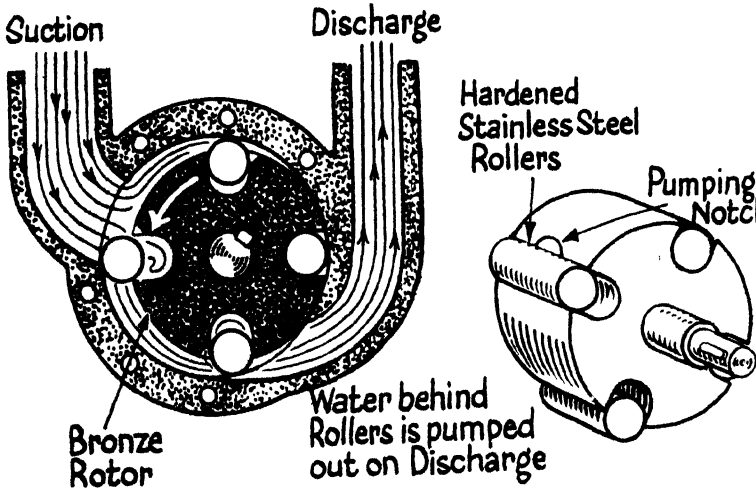
Exploded view of an *Axial Flow Pump.* These are often of large size, mounted horizontally.

Two other rotaries are illustrated, first, the gear type in which a pair of gears meshing together, and fitting closely in their casing, are interposed in the water pipe. As can be seen, the water stream is divided into two parts, each half being carried around the half casing in the spaces between the wheel teeth to be discharged on the other side. Pumps of this sort can produce a very considerable pressure in the discharge branch. Many will recognise it as the almost universally employed type for circulating the lubricating oil in internal combustion engines.

The next drawing shows an interesting design made for fire-fighting pumps where a high pressure jet is required. It has something in common with the vane pump (and motor) described in the chapter on compressed air, but it has hardened

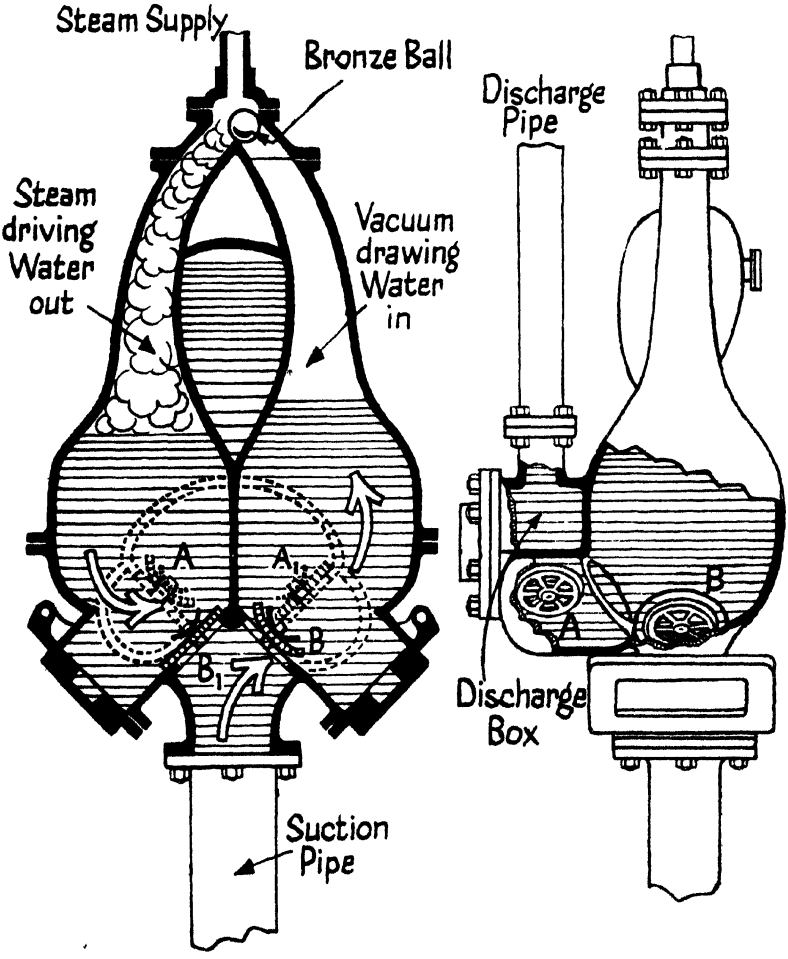


The Simble Gear Type Pump. Water is carried round in the spaces between the teeth.



An interesting form of *Rotary Pump* giving a high velocity discharge for fire-fighting.

stainless steel rollers instead of vanes. These rollers fly out under centrifugal action from their slots cut in the eccentrically mounted rotor, and as they are pushed back by the casing, perform a powerful pumping action in driving out the water that gets into the slots behind. A notch is cut out of the side of the slot to assist this action. The rotor is driven at considerable speed. Whether any of these pumps have been fitted



The valuable *Pulsometer Pump*. These sections help to explain how it works.

up for general work we do not know, but it seems likely that such will be the case presently. Water-jetting is something they could do very well.

We cannot leave this subject of pumps without a mention of a very old friend indeed, the Pulsometer Pump, not so often seen now that the oil engine has ousted the steam boiler from the field to the extent we have seen in the last 12 years or so. This pump wants steam to work it, and nothing else will do, some engineers think it uses rather a lot, but there is no doubt about its reliability. It could be hung by a rope or chains into the depths of a pit and would send up a continuous stream of water so long as there was any water there and its steam supply was maintained. How does it work ?

Look at the sectioned diagram, this shows there are two halves, exactly similar, with valves to admit water from the suction pipe and to close under pressure from inside. Two more valves open into the discharge box. A bronze ball rests on one or other of the small openings at the necks of the top, this controls the inlet of steam into the chambers.

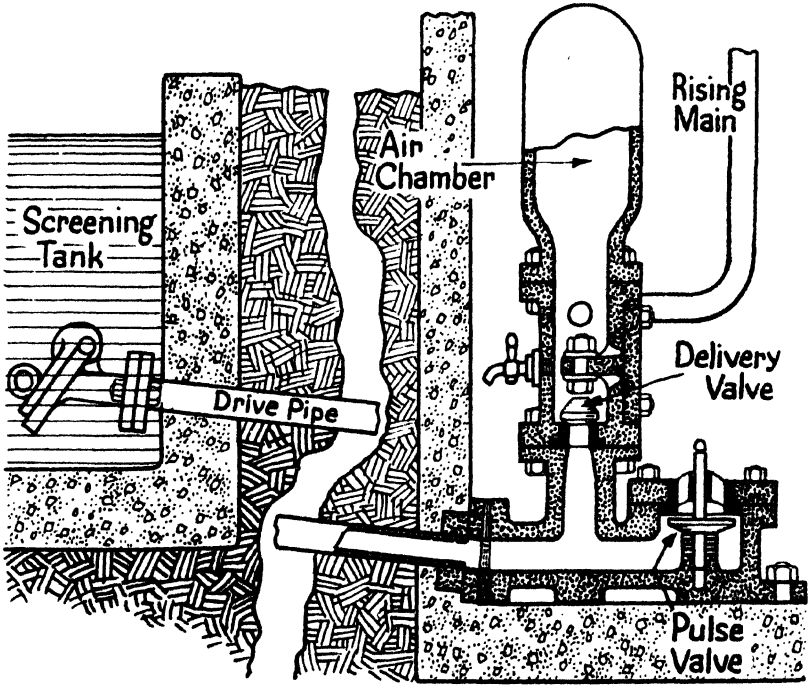
Taking the drawing as it is, steam is entering at the left-hand side, driving the water out into the discharging box. When the water gets to the level of the valve, there is a rush of steam and this sets up some commotion on the water surface, to condense the steam, so a vacuum is set up. This sucks the control ball over to seal the left hand neck, admitting steam on the right, where a full chamber waits. This water is driven down and the vacuum on the left draws water in to fill that side, though previously to this a small amount of air is drawn in to form a cushion between water and steam. This is the whole sequence, for the steam driving down the water on the right brings up to exactly the same state of things with which we began, only it was on the other side.

As can be seen, its working depends on the creation of a vacuum by condensing steam, so nothing but steam will work it. The purpose of the air cushion is to keep steam and water apart until that bit of commotion at the end of the blowing-out stage, otherwise condensation would begin too soon. It also cushions the motion of the ball as that changes its position from side to side.

The Pulsometer can handle water that might be better described as liquid mud, so it was much in favour in its day,

perhaps it is more employed still than we realise.

To finish off, here is an older device even than the Pulsometer, the Hydraulic Ram. This, though hardly to be reckoned as a regular piece of equipment for the contractor, has often filled a useful role as a lifter of water requiring no power whatever



Sections of the necessary details of the *Hydraulic Ram.*

once it is installed. A diagram illustrates the thing in section. What is necessary is a running stream where a fall of at least 10 feet can be arranged. From the stream a supply is drawn to keep a straining tank filled, and from that point a pipe not less than one inch diameter leads the water flow to the ram, installed in a pit as much lower than the stream as possible and not less than ten feet below. From here the water runs off and away.

All the water runs through the ram and out by way of the pulse valve, but when it has reached a certain speed the valve is thrown up suddenly, diverting the flow through the delivery valve and up the rising main to the storage tank. Pressure

thus relieved, the pulse valve drops, and the flow recommences that way. The sequence continues, the delivery valve traps the water in the rising main, to be lifted again when pressure has lifted the pulse valve once more. In regular service this action recurs about 45 times a minute. Of course, only a small part of the water is actually lifted into the tank, this varies according to conditions—height of delivery and height of fall of the drive water. Here are some figures.

A lift of 100 feet to the tank is required, and 10 gallons a minute of drive water is available with a fall of 10 feet. To achieve success, the drive pipe must be at least 81 feet long, and with these conditions, 400 gallons or more of water will find their way into the tank in 24 hours. If the pipes are good and clean, double this quantity may be expected, or even more. Higher falls, or larger quantities of drive water will put thousands of gallons an hour into the storage tank. Given continuous supply the ram will go on working for years, one in the writer's experience supplied a large country house with all the water used for 11 years, working non-stop without any attention whatever.

Index

Air, compressed, 118
 water trap, 136
Angledozer, 48

Batching Plant, 172
Brush Cutter, 48
Bulldozer, 39, 47

Cable Control Unit, 54
Cams, 15
Carryall Scraper, 52
Caterpillar, 40
Chain Drives, 21
Clutches, 23, 98
Compressed Air, 26, 118
Compressor details, 119
Concrete, 166
 Batching Plant, 170, 172
 distribution, 187
 Mixers, 169, 176 *et seq.*
 Mixer Lorry, 185
 Pan Mixer, 182
 Pump, 187
 Regulus Mixer, 183
 Slump Test, 168
 Vibrators, 191
 water gauging, 179
Contracting, 31
Crane, buying a, 34
 Brakes, 74
 Derrick, 34, 71
 erection of, 76
 Gantry, 73
 Jib repairs, 73
 Locomotive, 66
 motions of, 65
 portable, 81
 Rapid, 84
 Safe Load, 70
 testing, 78
Creeper Tracks, 89
Compressor, Lobe type, 127
 Unloader, 125
 valves, 122
 Vane type, 126

Dam Construction, 160
Derrick, All-round, 80
 Mono-tower, 78, 186
De-watering, 61, 210
Diesel Piling Hammer, 159
Dog Clutch, 26
Drag Shovel, 103
Dragline, 105
Dredger, Suction, 36
Dredge, Ladder, 110
Drills, Bits, 135
 Pneumatic, 128
 Road Breaker, 132
 Rock, 131
Dumper, 58

Excavators, 87
 Multi-Bucket, 110

Fluid Flywheel, 24
Fordson Tractor, 62
Frog Rammer, 61

Gear wheels, 18
Grabs, 112
Grader, 55
Gunite, 193

Head, of water, 198
Hoist, barrow, 184
Horse Power, 12
Hydraulic Cartridge, 28
Hydraulic Ram, 220
Hydraulic Jack, 27
Hydraulics, 27

Ladder Dredge, 110
Larssen Piles, 154
Levers, Orders of, 10
 power of, 11

McKiernan Terry Hammer, 155
Mine Car Loader, 139
Mobiloader, 56

Navvy Mechanism, 89

Orolo Tractor, 45

Pile Driving, 145
 Extracting, 157
Piling Hammers, 147, 155, 159
 Larssen, 154
 Sheet, 154
Piles, concrete, 146, 154
 concrete points, 146
Power Take-off, 52, 54
Pneumatic Hoists, 141
 Motors, 142
Pulleys, 15
Pulsometer, 219
Pumps, 195
 Axial-flow, 215
 Centrifugal, 200
 Concrete, 187
 Diaphragm, 208, 213
 Fire, 205, 216
 Multi-stage, 206
 Ram, 202, 212
 Self-priming, 203
 Semi-rotary, 213
 Unchokeable, 205
 Village, 195

Rammer, Petrol, 59
 Frog, 61
Road Grader, 55
Rooter, 50

Scraper Conveyor, 174
Scrapers, 51
Screw, 15
Screwjack, 16
Sheet Piling, 154
Shovel, Luffing Boom, 103
Site Clearing, 46
Skimmer, 88
Spanish Windlass, 29
Soil Freezing, 62

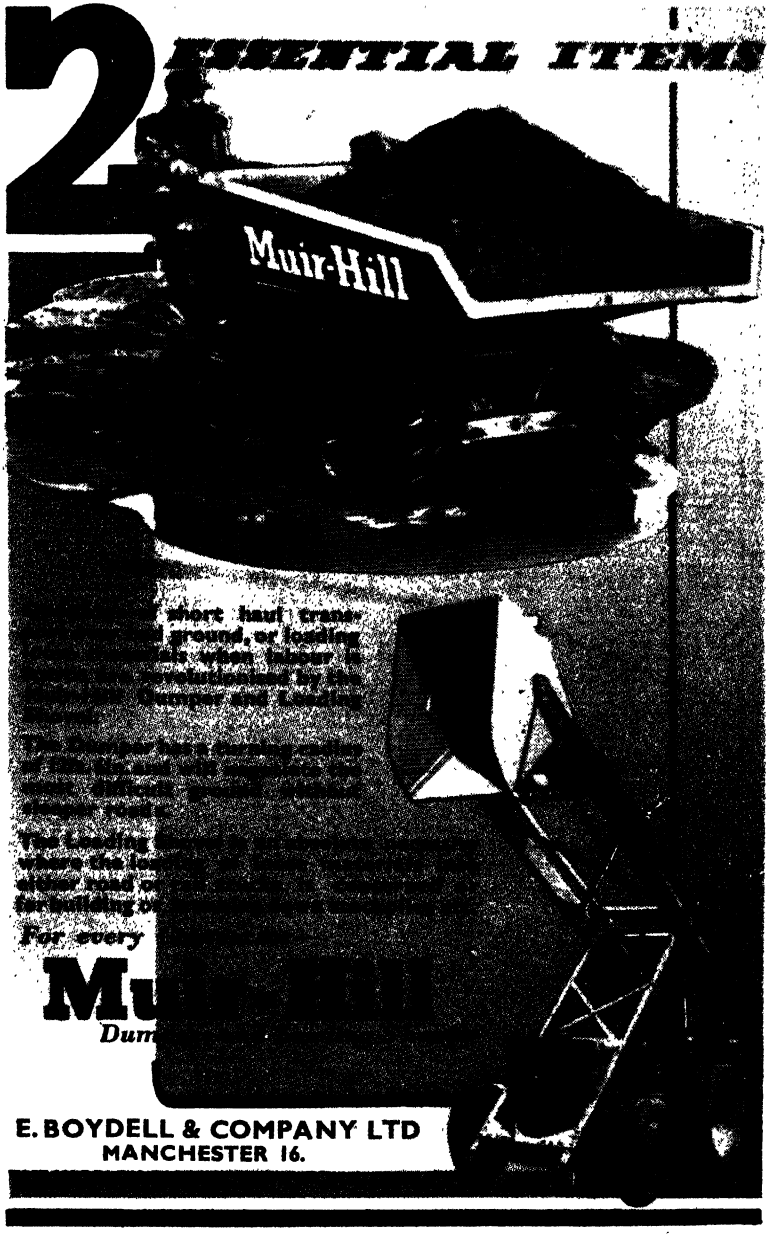
Toggle, 13
Tracklayers, 39, 89
 steering, 42
Tractor, Fordson, 62
 Orolo, 45
 Speeds, 44
Trencher, 103
Truck Mixed Concrete, 186
Tunnelling, 137

Unit of Work, 12

Vibrating Concrete, 191

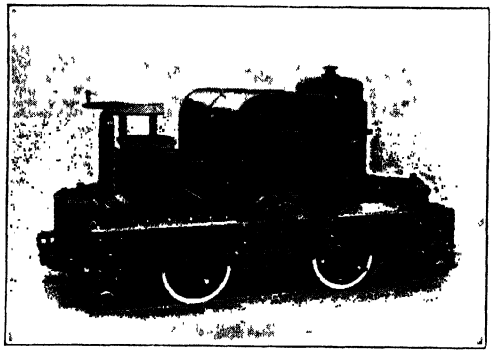
Water Jetting, 61, 165
Wedge, 14
Well Points, 61, 210
Weston Block, 18
Winches, Piling, 152
Wheel and Axle, 13
Worm Drives, 21

Printed in Great Britain by Hy. Ling Ltd., The Dorset Press, Dorchester, Dorset.


2
ESSENTIAL ITEMS
Muir-Hill
For every
E. BOYDELL & COMPANY LTD
MANCHESTER 16.

SIMPLEX

DIESEL LOCOMOTIVES



MOTOR RAIL

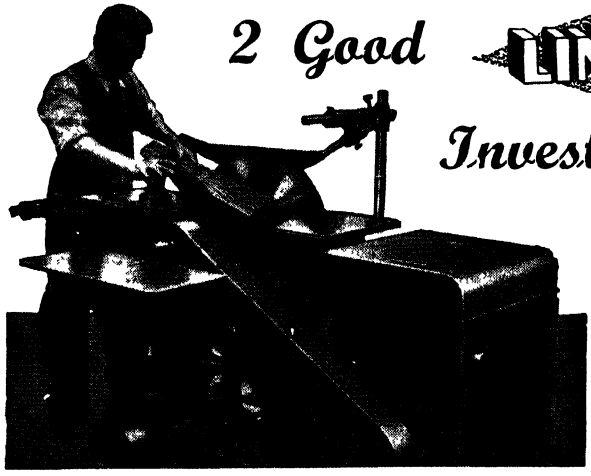
DIESEL DUMPERS



MOTOR RAIL LTD

SIMPLEX WORKS, :: BEDFORD

Telegrams : SIMPLEX BEDFORD *'Phone : BEDFORD 4521*



2 Good LINER Investments

The PORTASAW

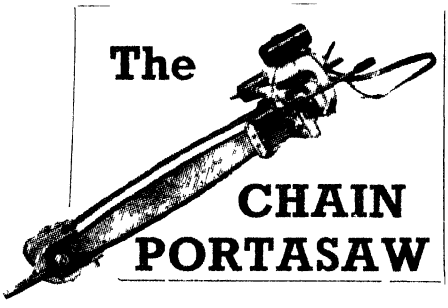
● An ingenious Portable Saw Bench driven by a compact, self-contained petrol engine requiring no skilled attention.

The "PORTASAW" rips, cross-cuts, bevels and bores right on the site.

It weighs only 11 cwt. and cuts up to 9 ins. in depth.

Let us send you full particulars.

Invaluable in Timber Yards or Woods, the CHAIN "PORTASAW" cuts at lightning speed. Two men can easily operate it. Instantly set for vertical, oblique or horizontal cuts. 3ft. 3in. and 4ft. 1in. sizes, fitted with petrol engine or electric motor. Write for full particulars.



LINER CONCRETE MACHINERY CO.,

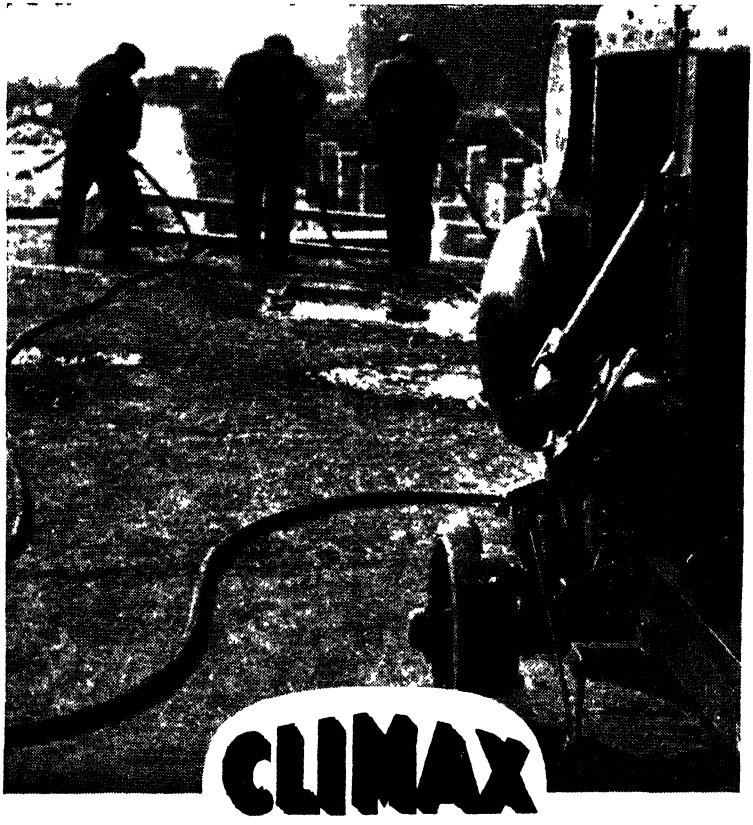
135, PARK ROAD, GATESHEAD, 8.

Telephone · Gateshead 72291.

LONDON OFFICE & SHOWROOMS 135, Liner House, Abbey Orchard St, Victoria St, S W.1

Also at Birmingham, Leicester, Manchester, Liverpool, Bristol, Leeds, Glasgow, Dundee, Belfast, Dublin, Etc (See Local Directory).

Reconstruction



Besides Air Compressors and Rock Drills, we make the most up-to-date Paving Breakers, Clay Diggers, Sump Pumps, Rammers, etc., etc. A request will bring you full particulars

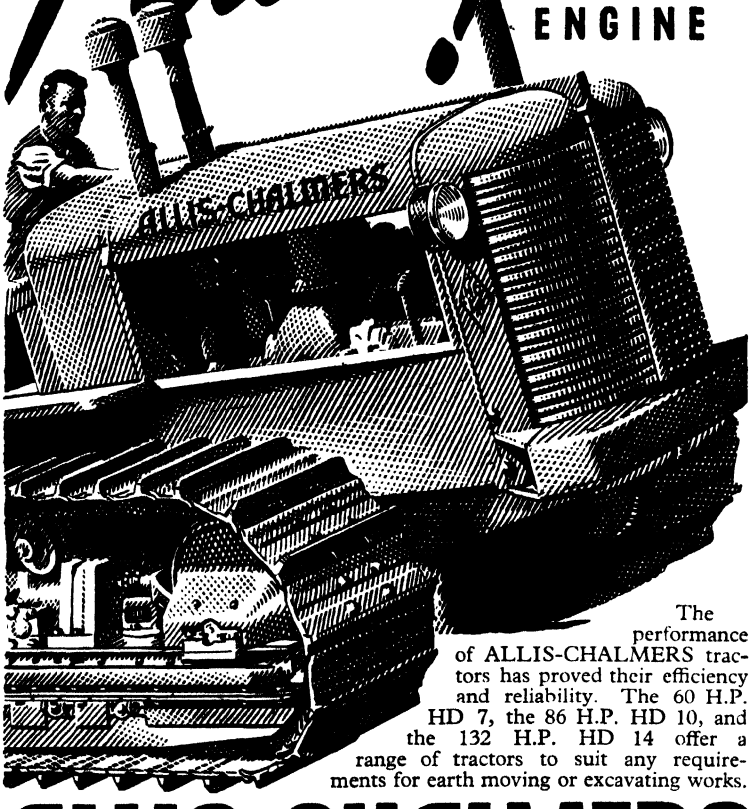
CLIMAX ROCK DRILL & ENGINEERING WORKS LTD.,
4, BROAD STREET LANE, LONDON, E. C. 2.
Works : CARN BREA, CORNWALL.

TAS/CX 407

E F F I C I E N C Y I N M O T I O N

Power!

G.M.C. ENGINE



The performance of ALLIS-CHALMERS tractors has proved their efficiency and reliability. The 60 H.P. HD 7, the 86 H.P. HD 10, and the 132 H.P. HD 14 offer a range of tractors to suit any requirements for earth moving or excavating works.

ALLIS-CHALMERS

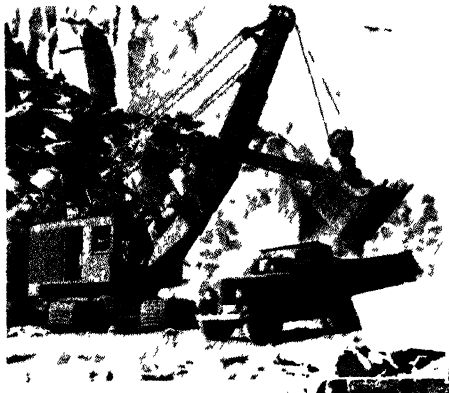
These tractors can be equipped by us with the finest design of Bulldozers, Angledozers, Scrapers and Winches, developed in conjunction with the ALLIS-CHALMERS organisation.

Sole agents for ALLIS-CHALMERS INDUSTRIAL TRACTORS and ancillary equipment by GAR WOOD, BUCKEYE, BAKER and CARCO; sole agents and stockists of above spares. Complete or field service overhauls at short notice.

MACKAY AGENCIES LIMITED

FAGGS RD., FELTHAM, MIDDLESEX. TEL: FELTHAM 3435-9

CONTRACTORS' PLANT



Blaw-Knox Equipment has all the qualities necessary to meet the exacting demands of the planners of Peacetime construction Experience gained in War is continually being turned to advantage in the range of equipment we offer to Contractors.



BLAW-KNOX

THE RANGE OF BLAW KNOX PRODUCTS — REX CONCRETE MIXERS CONCRETE PUMPS CONCRETE PAVERS CONCRETE SPREADERS & FINISHERS CENTRAL MIXING PLANTS CONCRETE BUCKETS BLAW KNOX COMBINE BATCHERPLANTS STEEL SHUTTERING ROADFORMS EXCAVATORS TRUCKMIXERS WEIGHBATCHERS STEEL STORAGE BINS DEWATERING PLANTS SCRAPERS BULLDOZERS ANGLEDOZERS RIPPERS SHEEPSFOOT TAMPING ROLLERS TRACTOR CRANES POWER CONTROL UNITS TRACTORS

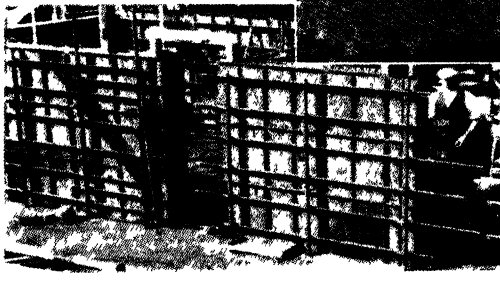




for Peace-time Construction

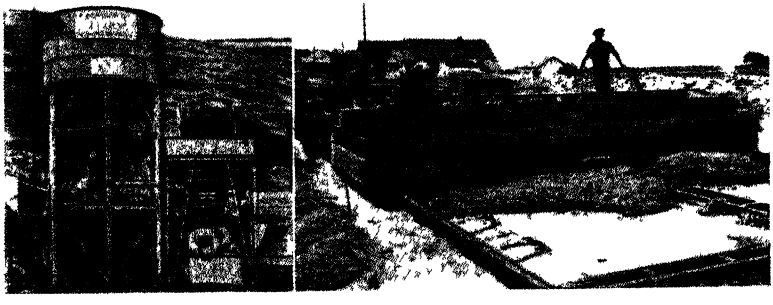
ILLUSTRATED ON LEFT — Northwest Excavator Road-Forms 12AV Scraper Bulldozer
ILLUSTRATED ON THIS PAGE — Trailer Mixer. Steel Shuttering: Bulk Cement & Central Mixing Plant: Concrete Spreader





BLAW-KNOX LTD.

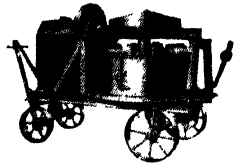
102 CLIFTON HOUSE, EUSTON RD., N W.1. EUS 5361



In every sphere
PERFORMANCE *is*

Safeguard your choice of plant by having before you the most up-to-date information on modern plant development. The latest PARKER Catalogue will give you the FACTS you need in deciding important plant investments.

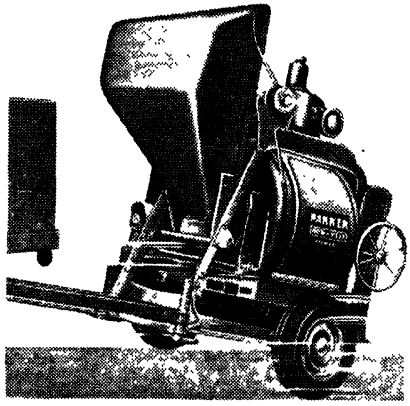




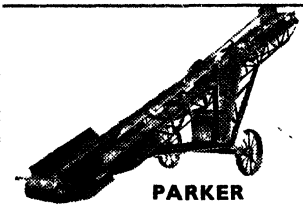
PARKER "OVEROLL" PAN MIXER



PARKER
LIGHT STONE BREAKER *with* **ENGINE**



PARKER HIGH-SPEED NON-TILT CONCRETE MIXER FAST TOWING TYPE
Also 4-wheel type for general service.



PARKER
PORTABLE BELT LOADER

PARKER PLANT

Proved Performance Pays!

FREDERICK PARKER Ltd. EXT: 40. VIADUCT WORKS, CATHERINE STREET, **LEICESTER**

'Phone : Leicester 61273 (4 lines)
Arundel Street, Strand, W.C.2.

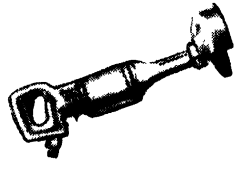
London Office : (Ext. 40) Talbot House.
Phone : 4239 & 2739 Temple Bar, London.

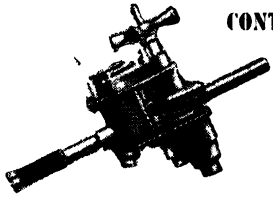
THROUGHOUT THE WORLD

EQUIPMENT for DURABLE SERVICE



AIR COMPRESSORS
PNEUMATIC TOOLS
ELECTRIC TOOLS
DIESEL ENGINES
VACUUM PUMPS
CONTRACTORS' EQUIPMENT
ROCK DRILLS
DIAMOND DRILLS
OIL WELL TOOLS

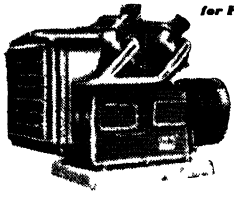


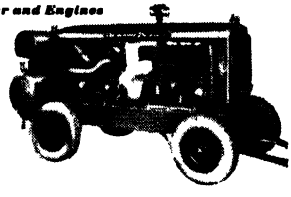




Sole Selling Agents for Duff Norton Jacks

Sole Selling Agents in Great Britain for Pikrose Haulage Gear and Engines





CONSOLIDATED PNEUMATIC TOOL CO. LTD.
232 DAWES ROAD LONDON SW6

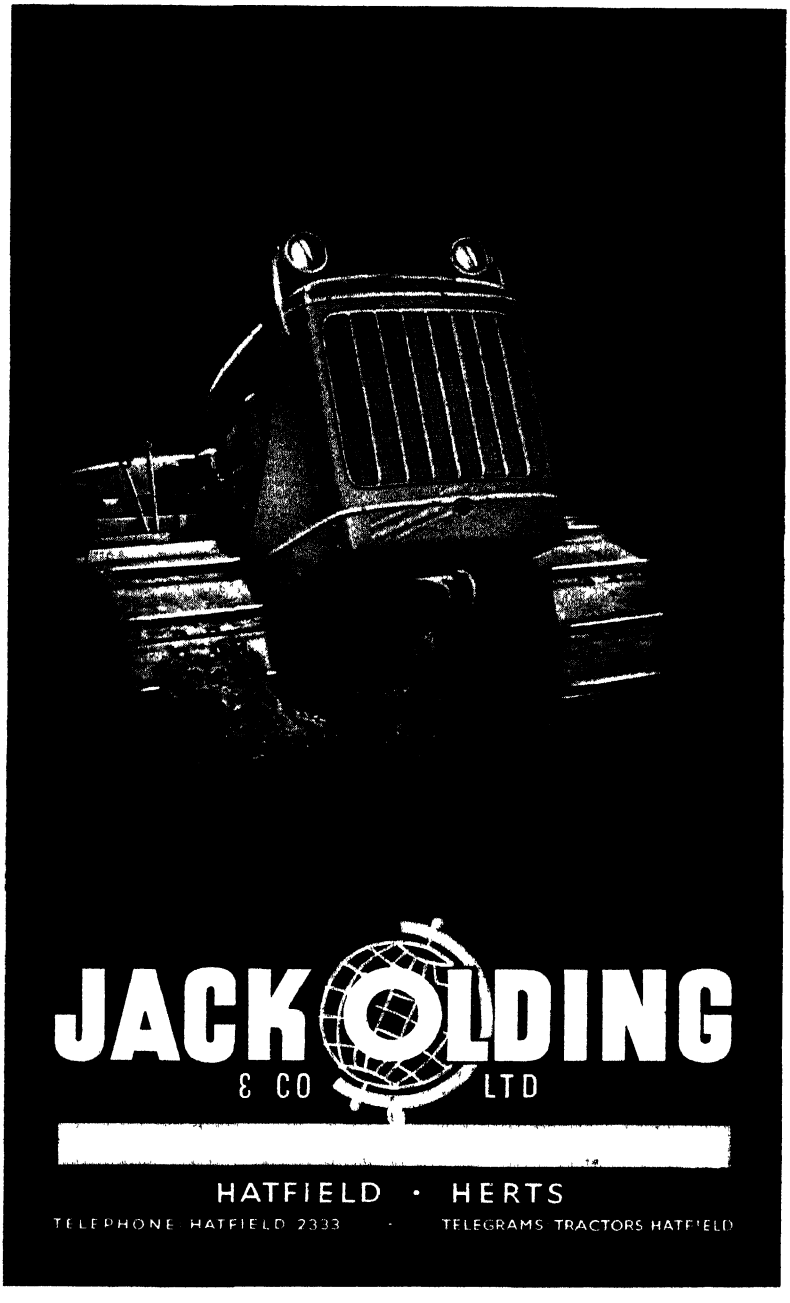
Robt. I. Story & Partners

C.A.V.
LIMITED

ELECTRICAL
& FUEL INJECTION EQUIPMENT



FOR
Distinguished
SERVICE


JACK OLDING
& CO LTD
HATFIELD · HERTS
TELEPHONE HATFIELD 2333 · TELEGRAMS TRACTORS HATFIELD

YESTERDAY'S DEFENCES

TOMORROW'S OBSTACLES TO PROGRESS BEING DEMOLISHED WITH HOLMAN EQUIPMENT



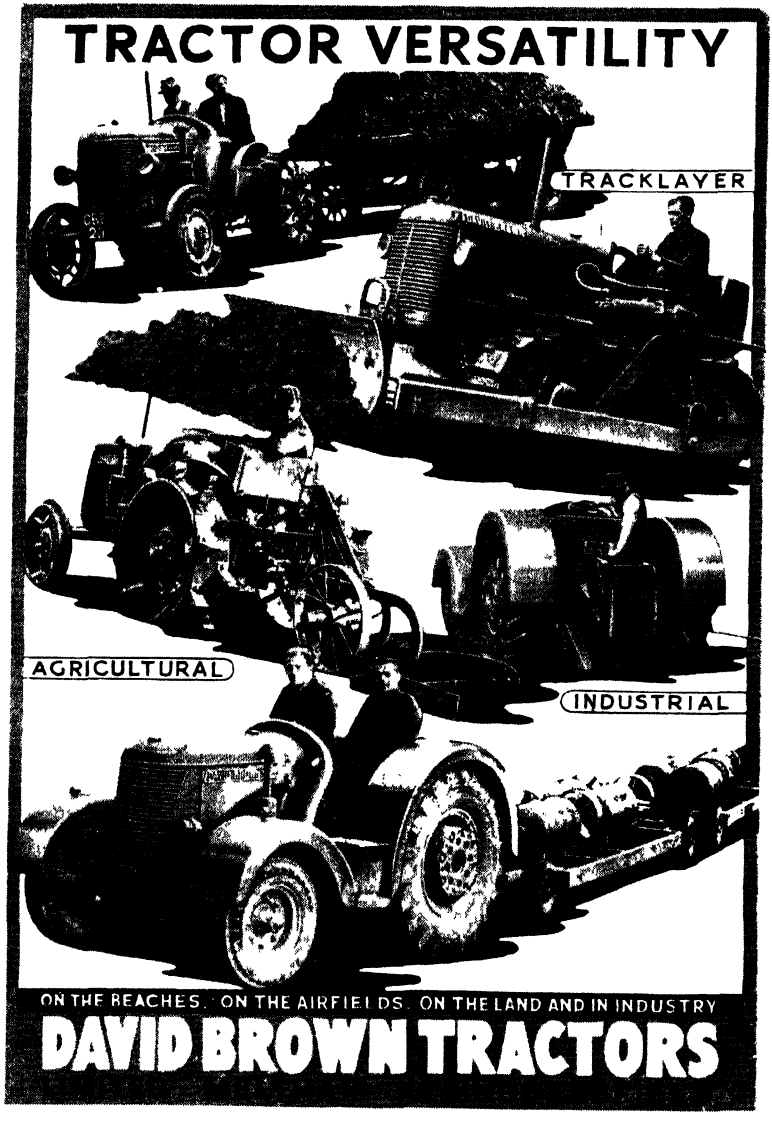
Compressed Air played its part in winning the War. Now it is assisting in rehabilitation at home by clearing away pill boxes, static water tanks, air raid shelters, and other unwanted structures.

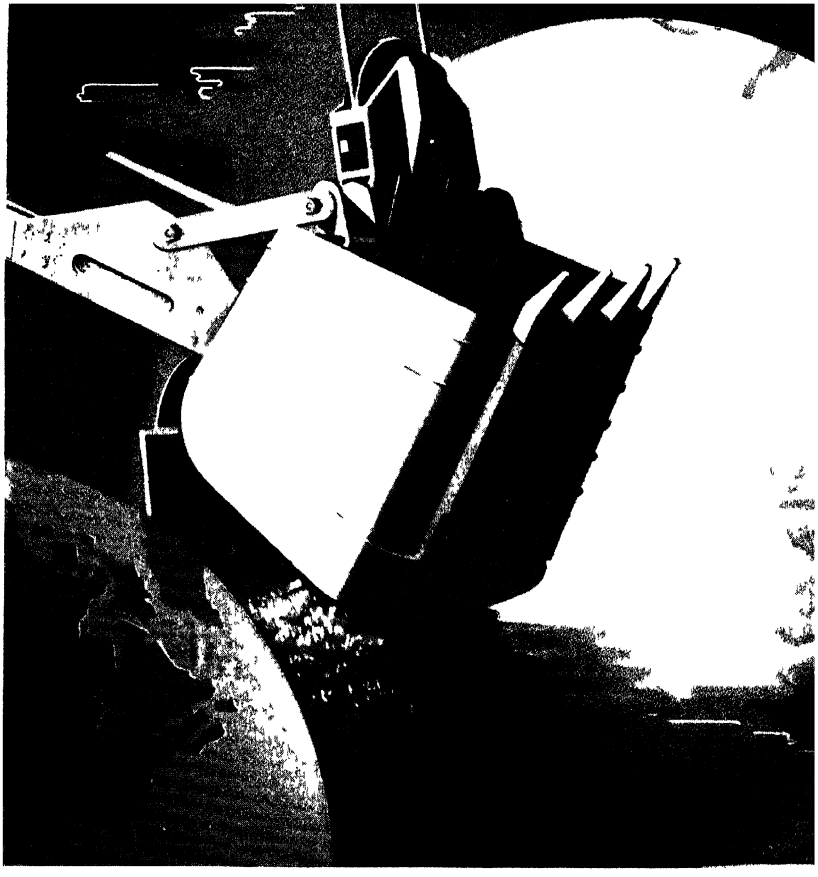
Holman BROS LTD
CAMBORNE - - - ENGLAND
Phone Camborne 2275 (7 lines)
Grams "Airdrill-Camborne"






READY for RECONSTRUCTION
KILWINNING
PETERBOROUGH
BEDFORD
LEIGHTON BUZZARD
CAMBERLEY
CHERTSEY
FERRIBY LINCS
CEMENT
CAMBRIDGE
TELEPHONE
WATERLOO
6900
BROXBOURNE HERTS
SAND & BALLAST
SHOEBURYNESS
STOCK BRICKS
SITTINGBOURNE
STOCK BRICKS
LEWES
CEMENT
Eastwoods Ltd
LONDON · S · E · 1


TRACTOR VERSATILITY
TRACKLAYER
AGRICULTURAL
INDUSTRIAL
ON THE BEACHES. ON THE AIRFIELDS. ON THE LAND AND IN INDUSTRY
DAVID BROWN TRACTORS



"In the right place-at the right time"

Yes, it is no small matter to ensure that plant, particularly modern excavators are in the right place at the right time. But excavators are indeed essential in modern contract work, they will retain their key position in this reconstruction period.

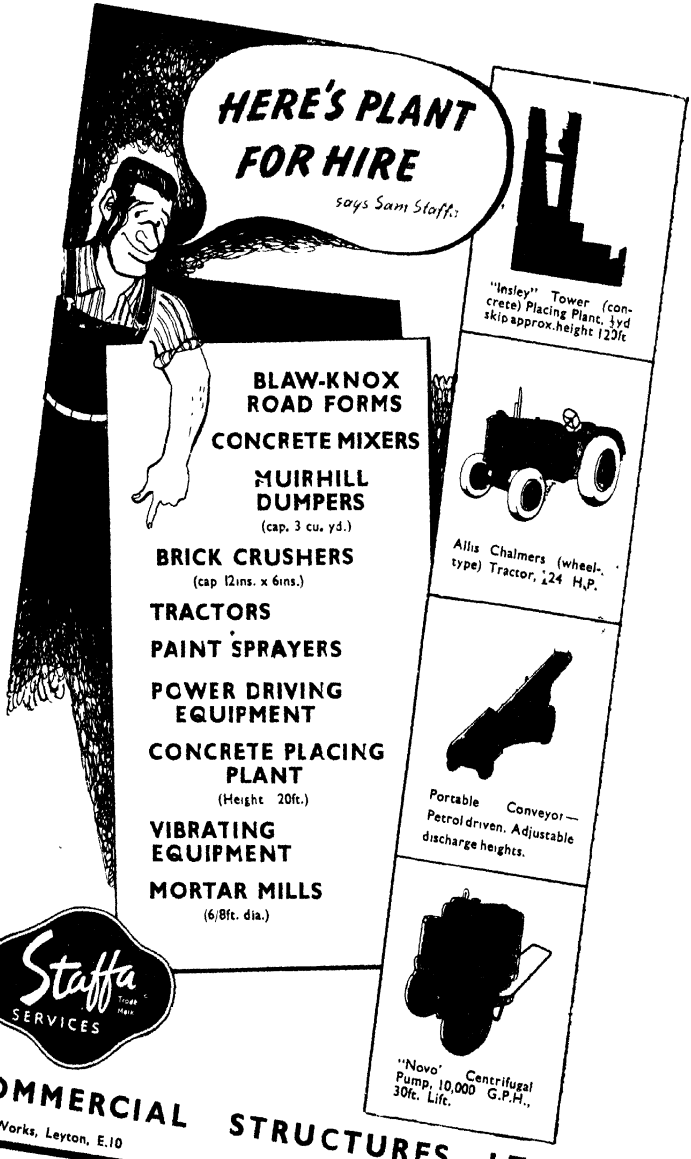
If you're wanting an excavator, or any other plant, now or in the future, be sure it will be there, with guaranteed maintenance from Plantire Ltd.

PLANTIRE LIMITED, 34 Victoria Street, S.W.I.

Bulldozers, Scrapers, Excavators, Air Compressors, Dumpers, Pumps Hoists. For Hire with Guaranteed Service.

HERE'S PLANT FOR HIRE

says Sam Staff:



BLAW-KNOX ROAD FORMS

CONCRETE MIXERS

MUIRHILL DUMPERS
(cap. 3 cu. yd.)

BRICK CRUSHERS
(cap 12ins. x 6ins.)

TRACTORS

PAINT SPRAYERS

POWER DRIVING EQUIPMENT

CONCRETE PLACING PLANT
(Height 20ft.)

VIBRATING EQUIPMENT

MORTAR MILLS
(6/8ft. dia.)

"Insley" Tower (concrete) Placing Plant, ¾yd skip approx.height 120ft

Allis Chalmers (wheel-type) Tractor, 124 H.P.

Portable Conveyor—Petrol driven. Adjustable discharge heights.

"Novo" Centrifugal Pump, 10,000 G.P.H., 30ft. Lift.

Staffa SERVICES

COMMERCIAL STRUCTURES LTD

Staffa Works, Leyton, E.10

LEYtonstone 3678

TASKERS

have specialised in designing and making

TRAILERS *for carrying all types of*

Contractors' Plant and Machinery

STANDARD INDEPENDENT and SEMI-TRAILERS

are available for carrying loads up to 25 tons

GOOD PLANT DESERVES GOOD VEHICLES

TASKERS OF ANDOVER (1932) Ltd., Waterloo Iron Works, Andover



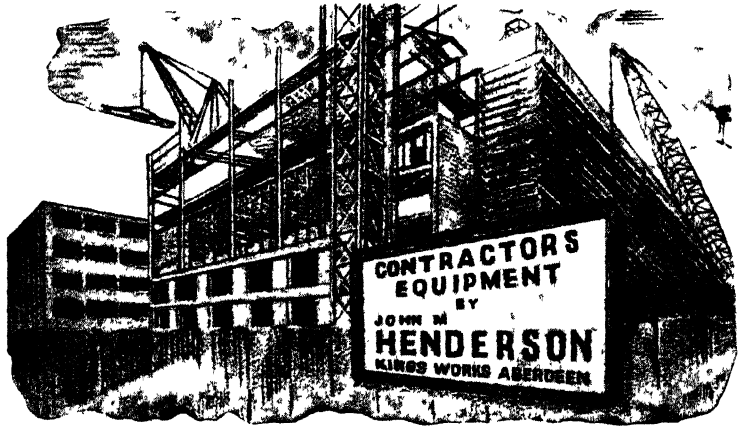
Henderson 5 ton Electric Derrick Crane used in conjunction with Henderson Aerial Cableways on the construction of the Hawswater Dam

Henderson Productions

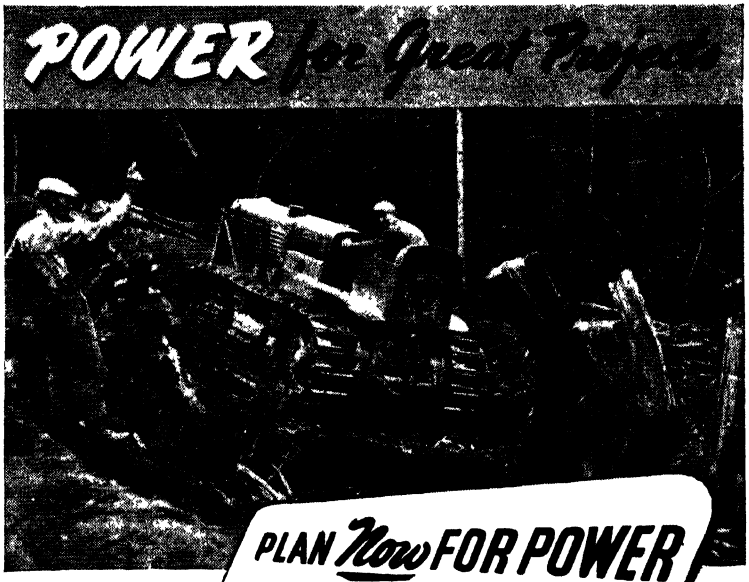
Manufacturers of Aerial Cableways, Aerial Ropeways, Aerial Cableway Dragline Excavators, Cable Drag Scrapers Cranes of all types Conveyors Coal and Ash Handling Plant, Crushing and Grinding Mills Haulage Gears Winches and Slipways, Hoist-conveyors and Runways Quarry Plant Skip Hoists Suspension Bridges Telphers Transporters Wagon Tipplers etc

A new publication

Copies of a new publication describing Henderson Products are now available Copies will be sent upon request



JOHN M HENDERSON & CO LTD, KINGS WORKS ABERDEEN



PLAN *Now* FOR POWER FOR POST WAR CONSTRUCTION

Great construction projects await us. There are airports, highways, bridges, dams to build, land clearing, and housing plans to be activated. All will require power of the kind that has made the name International famous.

Think now of International Power — TracTracTors, Wheel Tractors, and Power Units — in relation to your post-war plans. These tractors and power units, designed and built by International Harvester, are in sizes adapting them to a multiplicity of jobs. Into their design and construction goes the know-how that has made International Harvester the world's leading tractor producer.

Symbol of IH Service

INTERNATIONAL HARVESTER C°

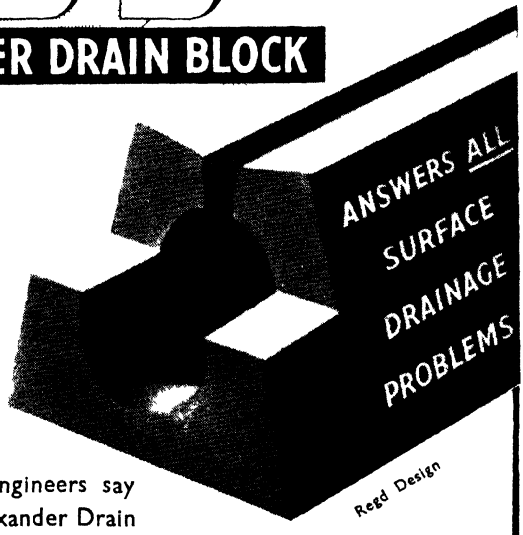
OF GREAT BRITAIN LIMITED

CITY ROAD LONDON E C 1

The

ADB

ALEXANDER DRAIN BLOCK



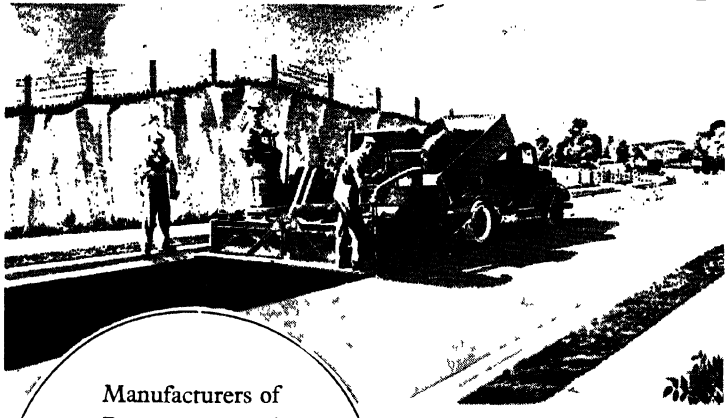
● Many civil engineers say that the Alexander Drain Block is the most efficient surface-drainage system ever invented . . . let our booklet tell you the facts.

ALEXANDER PRODUCTS LTD

Stoke Bishop **Bristol 9**

Telephone: Bristol 81002 *Telegrams: "Bulldozers" Bristol*

ROAD SURFACING



Manufacturers of
Bituminous and
Tar Emulsions
"Solutas" "Solutar"
Asphalt Manufacturers.
Specialists in Concrete.
Site Clearance
and Drainage.

Modern
Road
Pavior

ALEXANDER ASPHALT Co LTD

Stoke Bishop Bristol 9

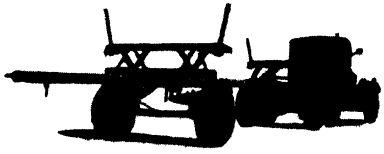
Telephone: *Bristol* 81002 *Telegrams*: "*Bulldozers*," *Bristol*

Multiwheeler

TRAILERS
AND
SEMI-TRAILERS



FOR ALL
LOADS
AND
TONNAGES

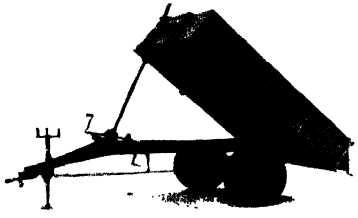


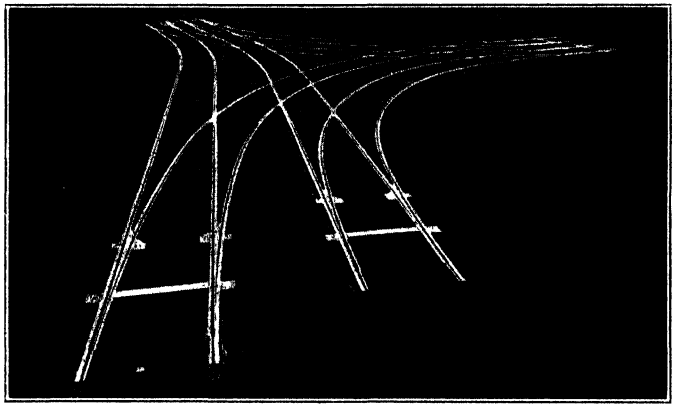
MULTIWHEELERS,

(COMMERCIAL VEHICLES) LTD.

SOUTH HARROW, MDX.

PHONE : Byron 1880
TELEGRAMS : Multiwheel, Phone.
London.





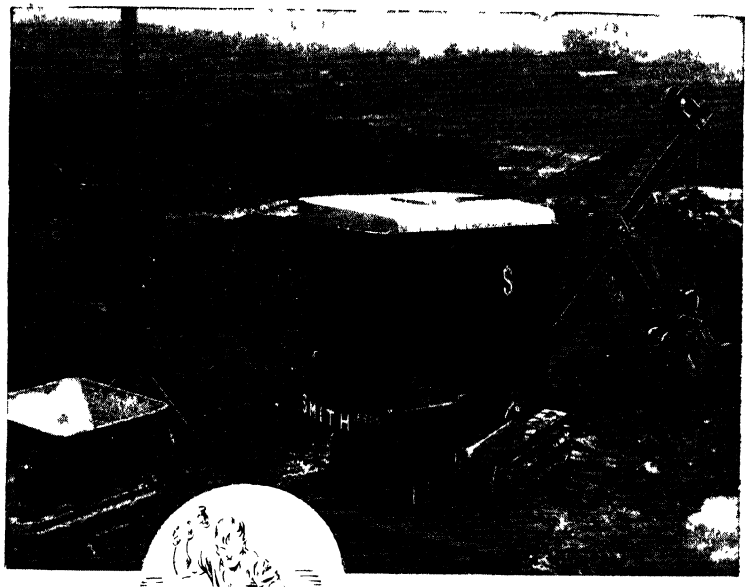
EDGAR ALLEN & CO. LTD.
Manufacturers of—

- PERMANENT WAY LAYOUTS
- SWITCHES & CROSSINGS IN ALL SECTIONS OF RAILS TO BRITISH STANDARD SPECIFICATION
- ALLEN'S IMPERIAL MANGANESE STEEL (BOTH ROLLED AND CAST) FOR RAILWAYS AND TRAMWAYS
- PRESSED STEEL CHAIRS, BUFFER STOPS, MANGANESE AXLE-BOX LINERS, ETC.

★
LAYOUTS IN 126·2 LB.
DOCKS SECTION FOR WHARVES,
WORKS YARDS & ANY POSITION
WHERE A LEVEL ROAD IS ESSENTIAL

Enquiries invited—

EDGAR ALLEN & CO. LTD.
IMPERIAL STEEL WORKS SHEFFIELD·9



The SMITH at work!

Responsive to control, dependable in performance, the SMITH "Seven" is true to the traditions of the bigger SMITH models. For digging earth and sand, clay or gravel, the "Seven" has been proved unbeatable in its class. With Diesel engine or electric drive; weighs 7¼ tons, bucket capacity 8 cu. ft.; output 10 to 35 cu. yds. per hour.

By interchange of jibs and front end equipment, the SMITH UNIVERSAL EXCAVATOR is quickly adapted to work as Navvy Shovel, Trencher, Skimmer, or Dragline.

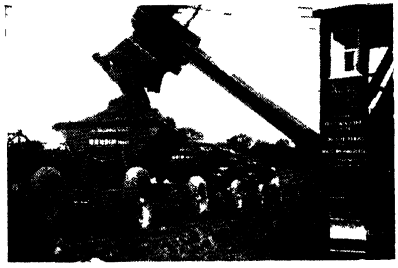
SMITH CRANES & EXCAVATORS

THOMAS SMITH & SONS (RODLEY) LTD. LEEDS

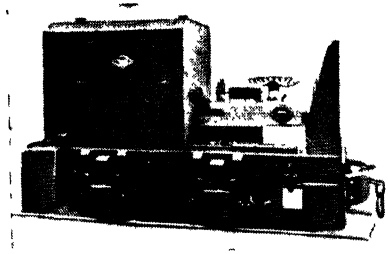
SPECIALISTS IN THE DESIGN & MANUFACTURE OF CRANES AND EXCAVATORS

Modern
MATERIAL HANDLING PLANT

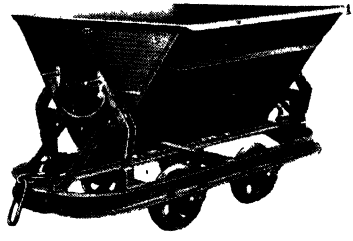
Material handling is speeded up to a remarkable degree with WILLIAM JONES equipment. The top photo shows a train of the well-known "DOBBIN" Tip Wagons (Pat. Nos. 450353 and 475161) lined up against the job for loading, ready to get away with a full load the fast, economical way that needs less manpower.



The "MONTANIA" Diesel Loco (centre) is to be found working all over the country, doing heavy haulage at low maintenance and fuel costs. The bottom illustration shows the popular "EXCELSIOR" Steel Tipping Wagon . . . side and end tip . . . with reinforced rims, patent dodger and "EXCELSIOR" roller bearing axle-box. Capacities from ½ to 1½ cu. yds. And, finally,



WILLIAM JONES have all types and sizes of turntables available as well as switches and crossings in every section of rail and gauge. For full information of these and other modern material handling plant, write :



WILLIAM JONES LTD

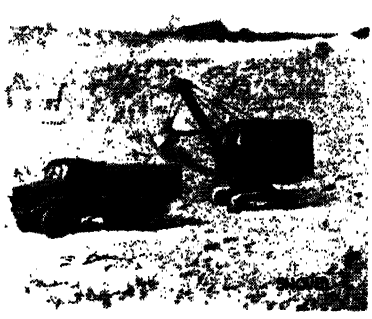
KINGSWAY HOUSE, KINGSWAY, LONDON, W.C.2

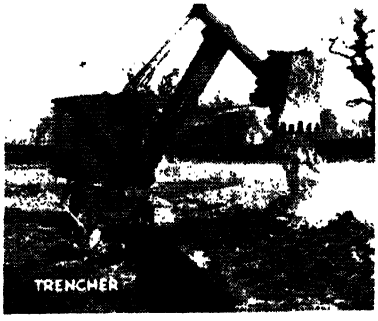
Telephone : Chancery 6191 (5 lines) *Telegrams : "Dianthus, Phone, London"*

Also at **WESTMOOR STREET, CHARLTON, S E.7**

EXCAVATORS...

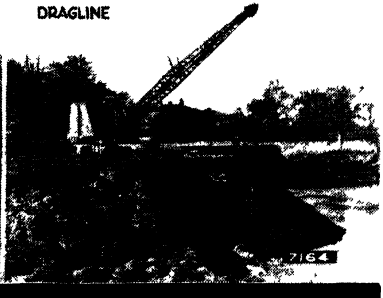
YOU CAN RELY ON "PRIESTMAN"





SKIMMER DRAGLINE





PRIESTMAN

BROTHERS LIMITED

EXCAVATORS - GRABS - DREDGERS

HULL AND LONDON



An invaluable service

SUPPORTING ALL RECONSTRUCTION WORK

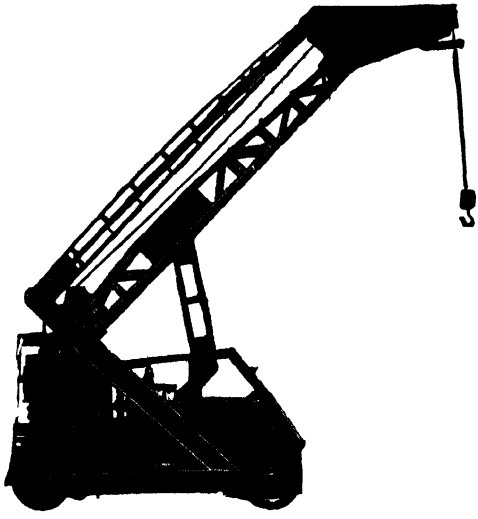
Realising that an idle tractor holds up production and involves unforeseen labour costs on the contract, Tractor Spares Ltd., made *prompt* replacement and repair service their one principle and as a result have built up one of the biggest British-made replacement spares businesses in the country to-day. If your tractor fails you, get in touch with "Tractor Spares" at once.

BRITISH MADE SPARES FOR

CATERPILLAR & INTERNATIONAL

Crawler
TRACTORS

TRACTOR SPARES LTD., WILLENHALL ROAD, WOLVERHAMPTON: TELEPHONE 21708 WOLVERHAMPTON: TELEGRAMS TRACSPARES WOLVERHAMPTON.



TATE

MOBILE CRANES

ELECTRIC • PETROL-ELECTRIC • DIESEL-ELECTRIC

12½ CWT. TO 5 TONS CAPACITY

FOR

- SPEED
- SIMPLICITY
- RELIABILITY
- LOW RUNNING COST
- LOW MAINTENANCE COST

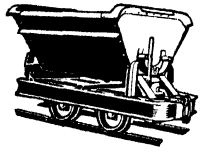
JAMES TATE & COMPANY

VICTORY WORKS

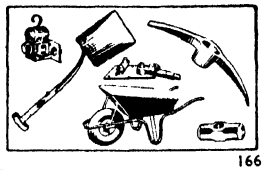
BRADFORD

PHONE : BFD. 9523

'GRAMS : VALVE BRADFORD



LIGHT
RAILWAY MATERIAL



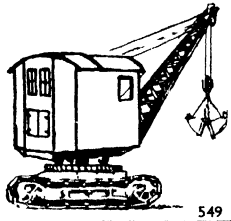
166

CONTRACTORS

TOOLS PLANT MACHINERY

M.E. Engineering Ltd

457 FINCHLEY ROAD
LONDON · N.W. 3
Phone · HAM 4365 · 2332



549

EXCAVATORS
COMPRESSORS
MIXERS
DUMPERS
TRACTORS

"MACO" TWO WHEELERS



815



Benjo

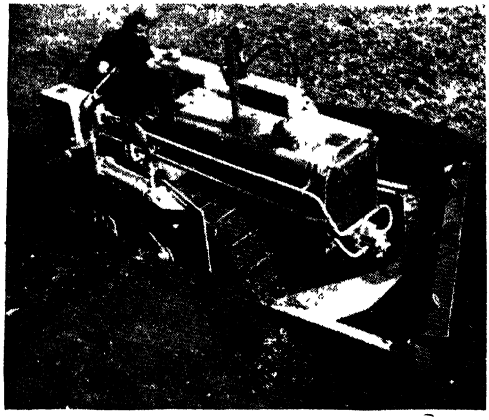
POWER RAMMERS

Reinstatement of inspection holes can present more difficult problems than yards of continuous trench, unless the backfilling is thoroughly consolidated.
The illustration shows how one Gas company ensured an easy mind on this point by using

BENJO POWER RAMMERS

B. JOHNSON & SON
Wharfdene, Skipton Rd, Ilkley, Yorks
London Rep. C. C. Ball, Esq.
130, VILLAGE WAY, PINNER, MIDDLESEX.

BRAY HYDRAULIC 'DOZERS



Hundreds of Bray 'Dozers, Hydraulic and Winch operated, are giving users the benefit of their high performance, rugged construction, accurate and positive blade control—the result of many years' experience on muck shifting plant manufacture.

Available for :—

ALLIS CHALMERS, CATERPILLAR, INTERNATIONAL AND CLETRAC TRACTORS

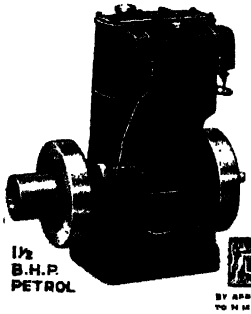
EARLY DELIVERY.

W. E. BRAY & CO.

ST. JOHN'S ROAD - ISLEWORTH - MIDDLESEX

'PHONE HOUNSLOW 0323.

BAMFORD



PETROL PARAFFIN & DIESEL MODELS *from* 1½ to 16 B.H.P.

Engines

IDEAL POWER UNITS for all INDUSTRIAL PURPOSES

BY APPOINTMENT TO H.M. THE KING

BAMFORDS LTD. UTTOXETER

Eliminate all loss from Rust and Corrosion

"SOZOL"

SCIENTIFIC RUST PREVENTIVE

"SOZOL", a thin non-inflammable liquid, renders all metal surfaces proof against rust, tarnish, and corrosion by one thin coating.

Protected in storage.
Lubricated in use.

PROTECT machines, spare parts, stores, shipping, motors, moulds, gauges from rust and corrosion in store, transit or shipment.

Agricultural Machinery
SOZOL

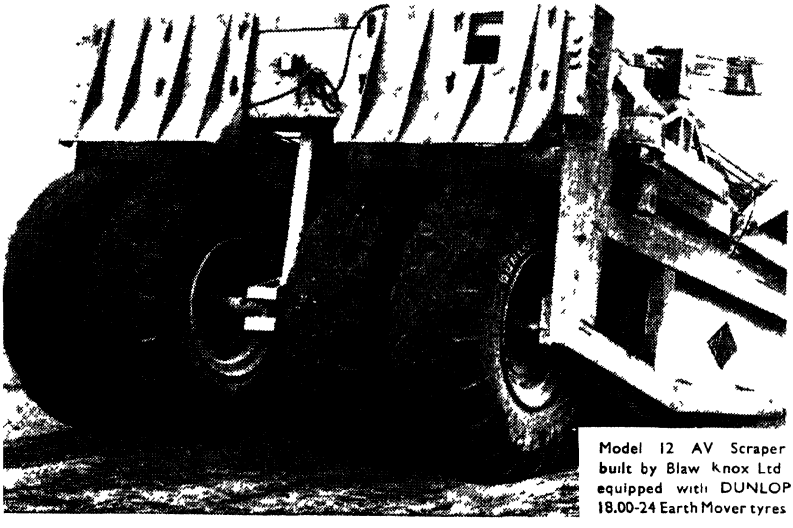
For Tractors, all farm implements, also Concrete mixers and excavators in store.

Full details, laboratory advice, prices, from

SOZOL (1924) LIMITED,
2, COPTHALL BUILDINGS,
LONDON, E.C.2.

DUNLOP

EARTH MOVER TYRES



Model 12 AV Scraper built by Blaw Knox Ltd equipped with DUNLOP 18.00-24 Earth Mover tyres

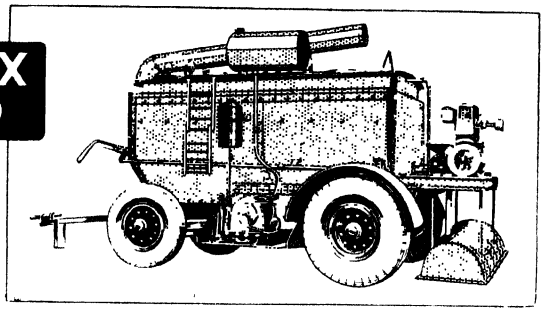
- built to take a gruelling!

These tyres carry heavy loads of materials across rough terrain in all weathers, and provide maximum performance under all conditions. Only specially built tyres of extremely robust construction could stand up to this test day after day.

DUNLOP — *MAKERS OF HISTORY IN RUBBER*

5L/502

PHŒNIX RAPID



TAR AND BITUMEN HEATER AND PRESSURE DISTRIBUTOR

For nearly fifty years, the Phoenix has specialised in the manufacture of Heaters, Spraying Machines and Mixers and other plant for road surfacing and maintenance work.

London Office
39 CHEAPSIDE · E.C.2

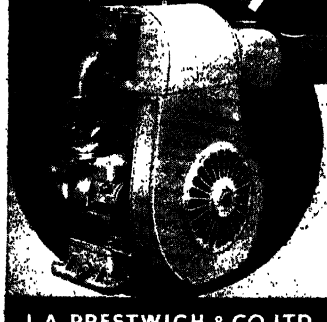
Telephone
CITY 3085

PHŒNIX

ENGINEERING COMPANY LTD
CHARD · SOMERSET
Telegrams: PHOENIX, CHARD *Telephone*: CHARD 3226

FOR TIRELESS ENERGY. . . . PLAR

The outstanding name in



ENGINES

INDUSTRIAL & AGRICULTURAL • AIR COMPRESSORS • ELECTRIC GENERATORS • WATER PUMPS Etc

J. A. PRESTWICH & CO. LTD., *ENGINEERS*, TOTTENHAM, LONDON, N.17

Specialists in the Manufacture of CONTRACTORS' PLANT

PORTABLE POWER RAMMERS.
DIESEL PILE DRIVERS.
COMPRESSORS *and* TOOLS.
BUILDERS' HOISTS.
PIPE LAYING WINCHES.
TIMBER DRAWERS.
CONCRETE VIBRATORS, AND SURFACERS.
PORTABLE PUMPS, BLOWERS.
PORTABLE CONVEYORS AND ELEVATORS.
SPECIALISED ENGINES.
COMPLETE HANDLING PLANTS DESIGNED *and* ERECTED.

SEND US YOUR ENQUIRIES !

C. H. JOHNSON (MACHINERY) LTD.
(Dept CPM) Adswood Rd., STOCKPORT, Eng.
Tel STOckport 2642/5 *(Est 1790)*

JOHNSON CONTRACTORS' PLANT

CHJ 364

R. WHITE & SONS (ENGINEERS) LTD.



Photograph shows **Automatic Loader** *actually loading 5½ tons of sand into lorry in 7 minutes.*

RAILWAY ENGINEERING WORKS
WIDNES
LANCS.

Makers of
AERIAL WIRE ROPEWAYS, CABLE WAYS, ROPE HAULAGES, POINTS AND CROSSINGS, TURNOUTS, TURNTABLES, PORTABLE TRAMWAYS, AUTOMATIC TIPPING WAGONS, LOADING MACHINES.

Telegrams . 'RAILS' WIDNES
Telephone : 2425 WIDNES



INTERNATIONAL

Offers FULL DIESEL OPERATION

plus choice of horse-power

FULL Diesel operation, plus choice of horse-power makes it more profitable than ever to standardise on the International Industrial Power line. Whatever the job, there is an International TracTracTor to get the work done. The big Model TD-18, the small Model TD-6, and the in-between sizes, Model TD-9 and Model TD-14 all give maximum power from FULL Diesel engines.

We, J. C. Oliver Ltd., are Main British Distributors of International TracTracTors fitted with

RUSTON-BUCYRUS

BULLGRADERS, BULLDOZERS, SCRAPERS, RIPPERS, etc.

and our Service facilities, in both Leeds and London are second to none in modern equipment, and trained personnel.

We are also Sole Distributors in Great Britain of :-

ADAMS Elevating & Motor GRADERS — MULTIFOOTE CONCRETE PAVERS — ADNUN BITUMEN PAVERS

OLIVER-EUCLID Crawler, Tu-Way Tipping WAGONS

Our facilities are at your disposal, and we invite your enquiries.

J. C. OLIVER LTD., Airedale Plant & Railway Works, LEEDS, 10

BURTON STREET, St. Pancras, LONDON, W.C.1.